INTERNATIONAL

Marine Engineering

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Fig. 1.—View of North Yard of New York Shipbuilding Corporation from Aeroplane

The Largest Shipyard in the World

When Charles M. Schwab took charge of the operations of the Emergency Fleet Corporation early in 1918 one of the first policies that he adopted was the immediate expansion, wherever possible, of the old established shipyards throughout the country. As a result, up to the end of hostilities practically all of the tonnage for our overseas operations was produced in the established yards, with their rapidly expanded facilities. One of the most striking examples of this expansion in the older yards can be found at the plant of the New York Shipbuilding Corporation, Camden, N. J., now the largest shipyard in the world, which is described and illustrated in the following pages.

TO anyone who has not had occasion during the past two years to visit the yards of the New York Shipbuilding Corporation at Camden, N. J., a trip through the plant to-day would be a startling revelation. Not only has the plant grown, in point of size, until it can rightfully claim the distinction of being the largest self-contained shipyard in the world, but in the diversity of its products and the completeness of its equipment and organization it has set a high-water mark in modern shipbuilding activities.

If figures alone would tell the story of the remarkable growth of this industrial plant, it might be sufficient to point out that during the war the number of building ways had increased from 10 to 28, the number of fitting out piers from 2 to 9, the number of employees from 3,800 to 18,000, the value of vessels under construction from $33,-

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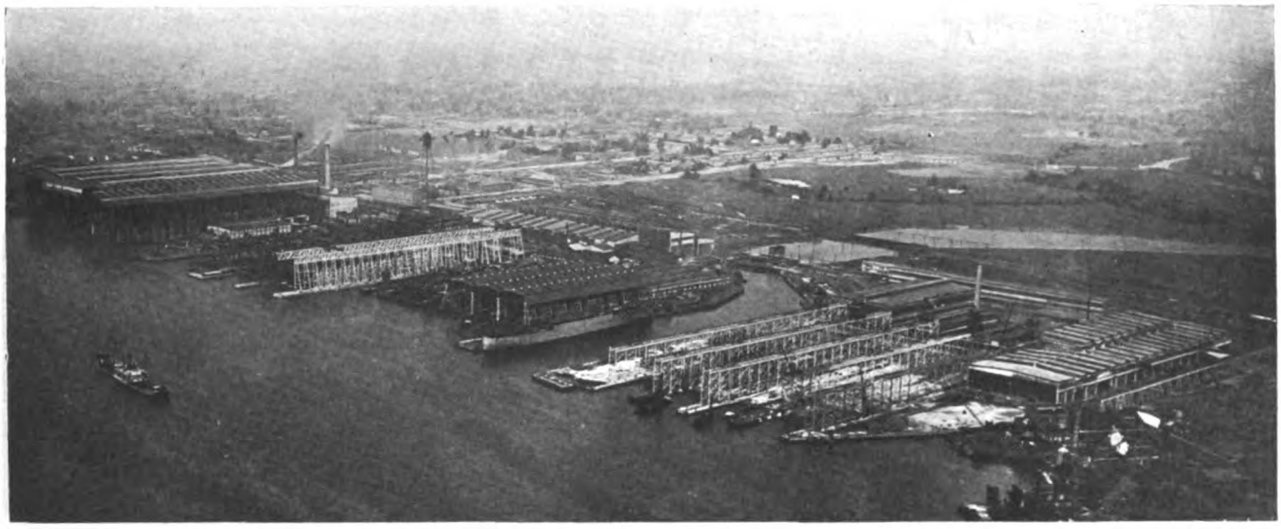

Fig. 2.—View of New York Shipbuilding Corporation Plant from Aeroplane, South Yard in Foreground

000,000 ($10,000,000 merchant and $23,000,000 naval) to $150,000,000 ($60,000,000 merchant and $90,000,000 naval), or that the payroll of the company had increased ten-fold, totaling last year $27,394,656.69. But figures alone do not tell the story, and it is only by an examination of the details of the plant and its method of operation that a true conception of its significance can be gained.

Before attempting to describe, even briefly, the recent extensions to the plant, we wish first to call attention to the output of the yard and the nature of the work now on hand. In 1919 the yard launched 87,580 gross tons of shipping and delivered 86,727 tons. The corresponding figures for 1918 were 72,032 gross tons launched and 77,283 gross tons delivered. The tonnage delivered during the war (1915 to 1918, inclusive) was 240,000 gross tons. Up to the end of 1919 the yard had launched 228 vessels aggregating 772,518 gross tons and 1,272,500 horsepower. Up to the end of 1917 the yearly average had been 36,050 tons launched and 34,700 tons delivered.

Work on Hand

At the beginning of the present year the work on hand included two battleships, each of 32,600 tons displacement; one battle cruiser of 43,500 tons displacement; twenty-two destroyers, each of 1,200 tons displacement; nine twin-screw passenger and cargo steamships, each of 13,500 gross tons; six passenger and cargo steamships, each of 11,000 gross tons; two freight steamers, each of 12,000 tons deadweight; and one oil tanker of 12,750 tons deadweight. Since the first of the year other contracts have been added to this list.

It must be remembered that during the period covered by the above figures the yard was greatly handicapped in its production by the fact that enormous extensions to the plant were being made while the balance of the plant was turning out the finished product, a condition which made it impracticable for the plant to maintain its maximum production. Further difficulties had to be faced during the war in that the established yards were obliged to supply many of the officers and leading men for the new yards, thus decreasing their own efficiency in order that the shipbuilding talent in the country might be disposed to the best advantage. During this period, also, material for light destroyers and heavy freighters had to be handled through the shops at the same time and the shortage of skilled labor made it necessary to maintain a training school in the plant, all of which, of course, mitigated against the maximum efficiency of production.

Fig. 3.—View of Yorkship Village from Aeroplane

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Fig. 5.—Typical Buildings at South Yard. (1) Carpenter Shop; (2) Administration Building; (3) Freight House; (4) Blacksmith Shop; (5) Copper and Machine Shops; (6) Gantry Shed; (7) Sanitary Shed; (8) Pump House, T and U Ways

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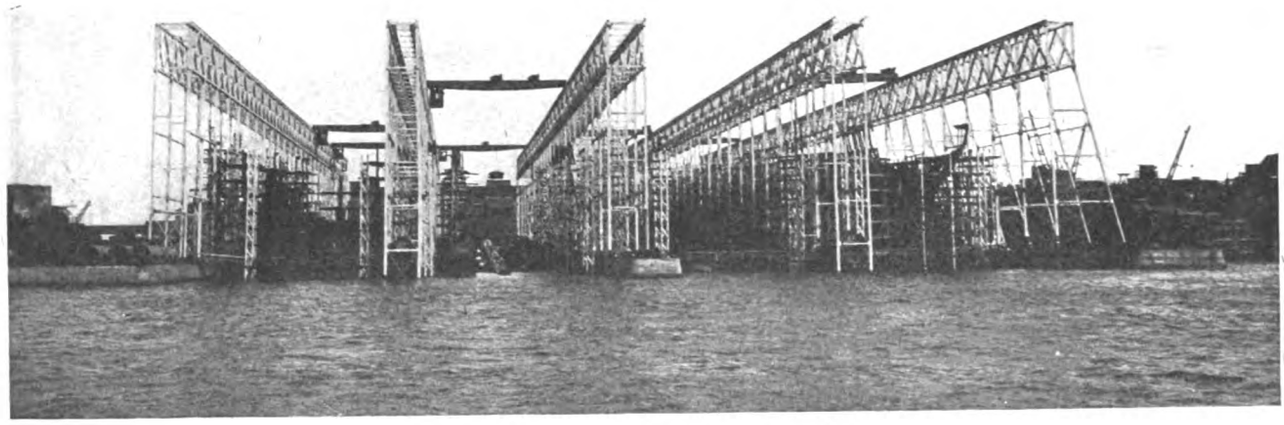

Fig. 6.—"T" and "U" Ways from the River

In view of this it is safe to assume that, if these conditions had not prevailed, the output of the yard would have been materially greater.

THE ORIGINAL YARD

In order to get a comprehensive idea of the extent of the additions that were made to the plant during the war, it will be necessary to refer to the plan of the plant shown in Fig. 4. As originally laid out in 1899 and built in 1900, the New York Shipbuilding yard extended in a southerly direction only to and including ways *L*. The entire plant, comprising buildings *B, C, D, E,* wet basin *H* and ways *J, K* and *L,* was under one roof and, with the exception of ways *M* and *O* only minor additions to the plant, consisting chiefly of new equipment, were made from the time of its completion in 1903 until the recent extensive additions were begun during the war.

The original plant was designed in accordance with three general principles which at that time were considered unique and, by many of the shipbuilders, even impracticable. These principles were as follows: First, the application of the bridge shop practice of template-making to shipbuilding for the fabrication of practically all structural material going into the ships; second, the combining of the entire plant in a series of connected buildings, under one roof, for the manufacture of all essential parts of the ships, with a system of overlapping traveling cranes to reach all parts of the buildings without dependence on connecting railway tracks; third, fully enclosed ship sheds connected to and operated under the same conditions as the manufacturing buildings.

As shown by the plan (Fig. 4) this arrangement was carried out in the original plant, or the north yard as it is now called, with an assembling space at the head of the ways for fabricated ship material, beyond which is the machine shop with the steel storage, boiler, angle and plate shops at one side, the plate and angle shops being virtually extensions of the assembly space at the head of the ways. This same arrangement, it will be seen, has been carried out in its essential details, but with modifications and improvements in the new south yard at the south end of the plant in connection with ways 1, 2, 3 and 4. That the principles underlying the arrangement and method of operation of this plant were sound and practical has been amply proved by the work turned out in the twenty years' existence of the plant and by their adoption in one form or another by many other shipbuilders.

BEGINNING OF THE EXPANSION

When the yard was taken over by the New York Shipbuilding Corporation, a subsidiary of the American International Corporation, in December, 1916, the plant extended only to the south side of ways *O*. The entire southern end of the property owned by the company, or practically two-thirds of the entire property, was wholly undeveloped. The first addition to the yard consisted of two new sets of ways designated on the plan, Fig. 4, as ways *T* and *U*, the construction of which began in March, 1917. Plans for the construction of these ways included

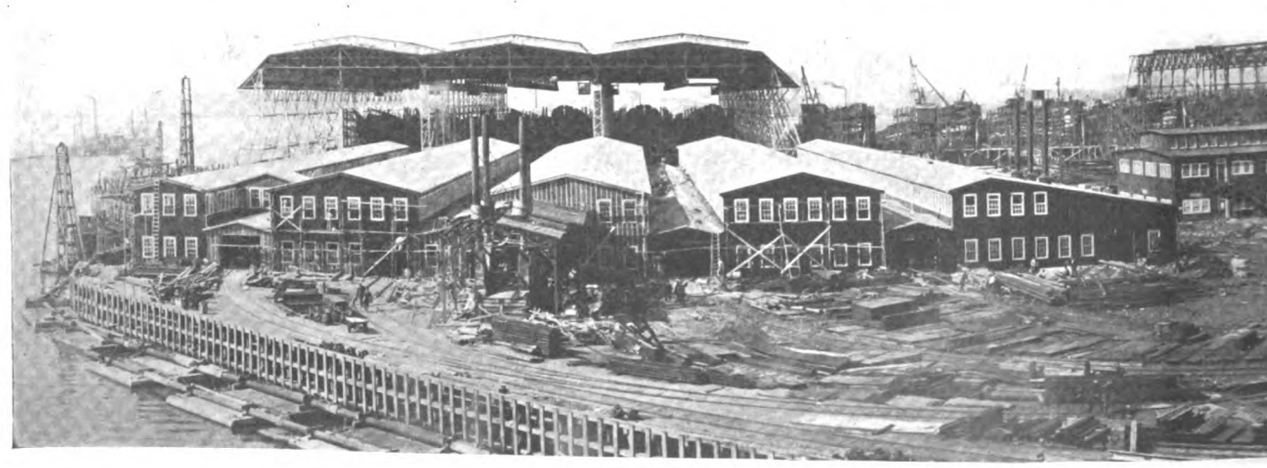

Fig. 7.—Destroyer Yard

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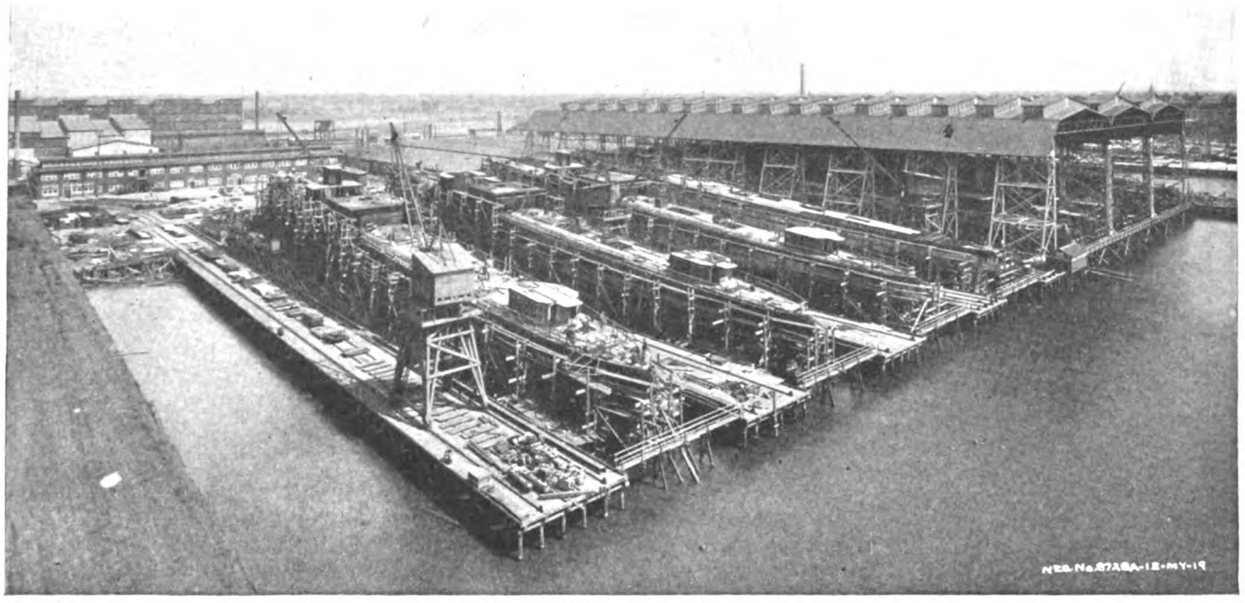

Fig. 8.—Destroyer Ways

Fig. 9.—Destroyers Being Fittted Out in Wet Dock

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Fig. 10.—Ways, South Yard

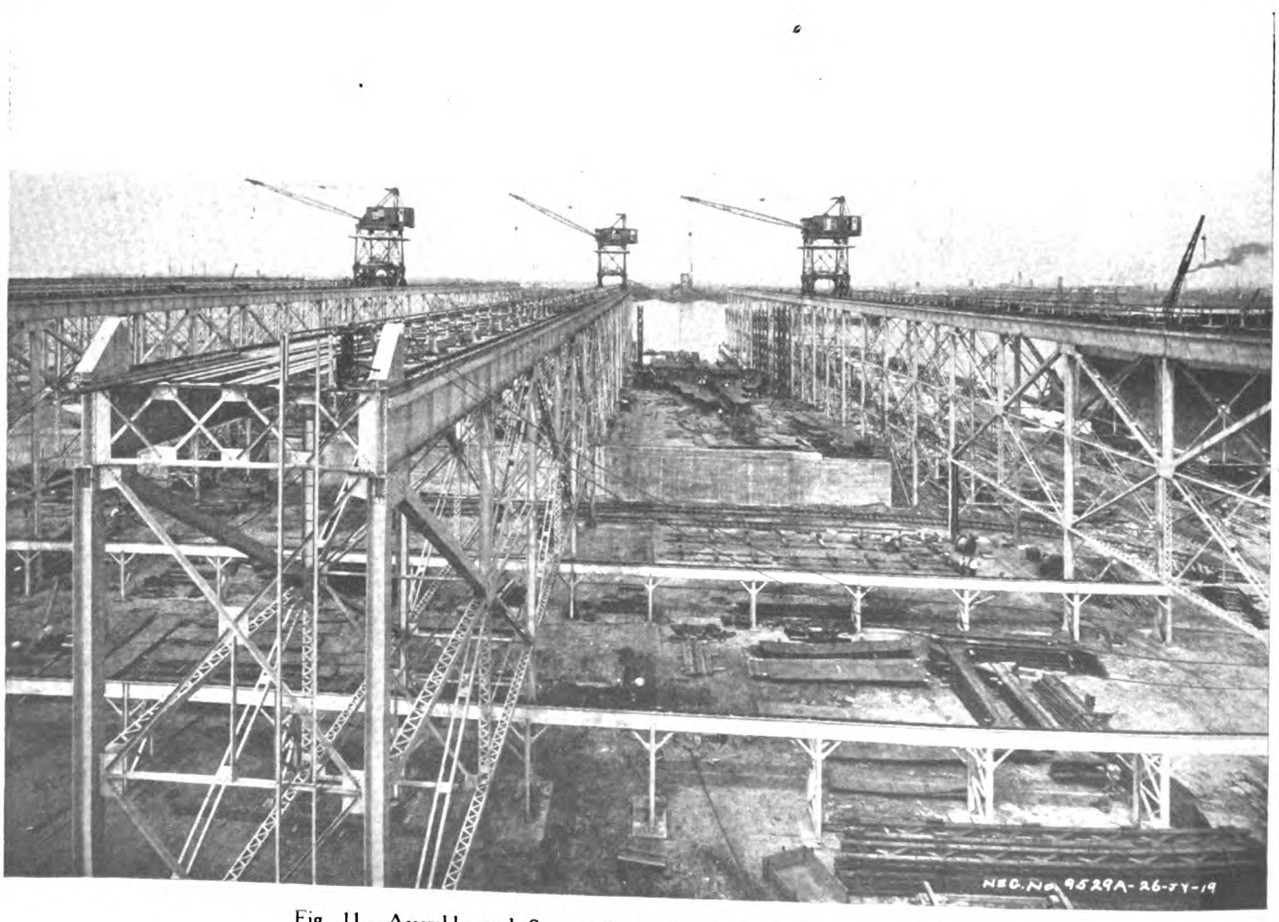

Fig. 11.—Assembly and Storage Space at Head of Ways, South Yard

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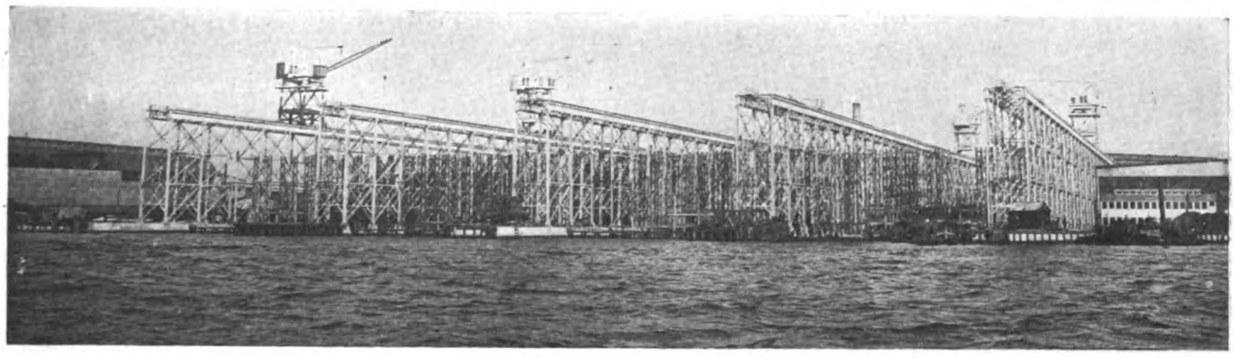

Fig. 12.—View of Ways, South Yard, from River

also the construction of a wet dock, 300 feet wide, on the north side of Pier 4. This dock was dredged by hydraulic dredges operated by the American Dredging Company of Philadelphia to a depth of 26 feet at low water and the material dredge out was pumped on to the site of ways *T* and *U*, filling out to the south side of Pier 5. Ways *T* and *U* are each 152 feet wide by 600 feet long, giving space for laying down four 500-foot vessels at a time. Plans for these ways contemplate their extension to twice their present length in order to accommodate vessels up to 1,000 feet in length.

T and *U* Ways

Ways *T* and *U* are of novel construction in that the ships built on these ways are erected directly on a sand foundation instead of the usual pile foundation. The ways themselves rest on concrete caps or sills, each 14 inches wide at the top, 24 inches wide at the bottom and 30 inches deep, spaced 5 feet apart. From the head of the ways down to the high-water mark, these sills are laid directly on the sand, but from there out the ways rest on wooden caps on wooden piles. In the old part of the plant, that is, ways *J*, *K*, *L* and *M*, the way foundations consist of wooden caps on wooden piles. The foundations for ways *O* consist of reinforced concrete caps on reinforced concrete piles. As a matter of fact, the new construction adopted for ways *T* and *U*, and used also in the development of the South yard, as will be mentioned later, cost only about one-third of the construction involving the use of pile foundations.

When the construction of *T* and *U* ways began the steel market was in such condition, due to the demands upon the steel mills from Europe, that it was impossible to get quick deliveries of steel for the superstructure for the ways, consequently a wooden superstructure was designed by E. H. Sapp, civil engineer of the plant, and erected by the McClintock-Marshall Company of New York, which has proved very successful. The first keel on these ways was laid in December, 1917. The first launching occurred on July 4, 1918, and at the end of 1919 ships had been launched from all four of these ways. The contract for pile driving and concrete work in the construction of these ways was handled by the Armstrong and Latta Company, Philadelphia.

While ways *T* and *U* were under construction, the lunch and locker building, south of ways *O*, was built. The construction of this was begun in November, 1917, the first floor of the building containing a locker room and the second floor a cafeteria capable of accommodating 700 men.

Complete Destroyer Yard Built

The next addition to the yard was the construction of a complete destroyer yard, the actual construction of

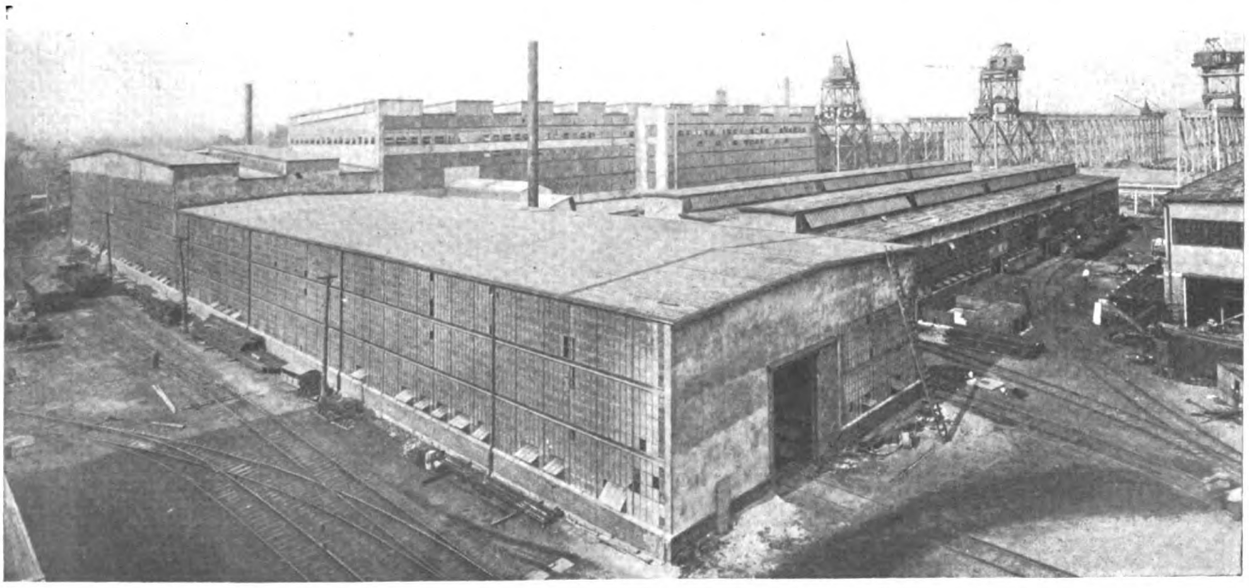

Fig. 13.—Plate and Angle Shop, South Yard

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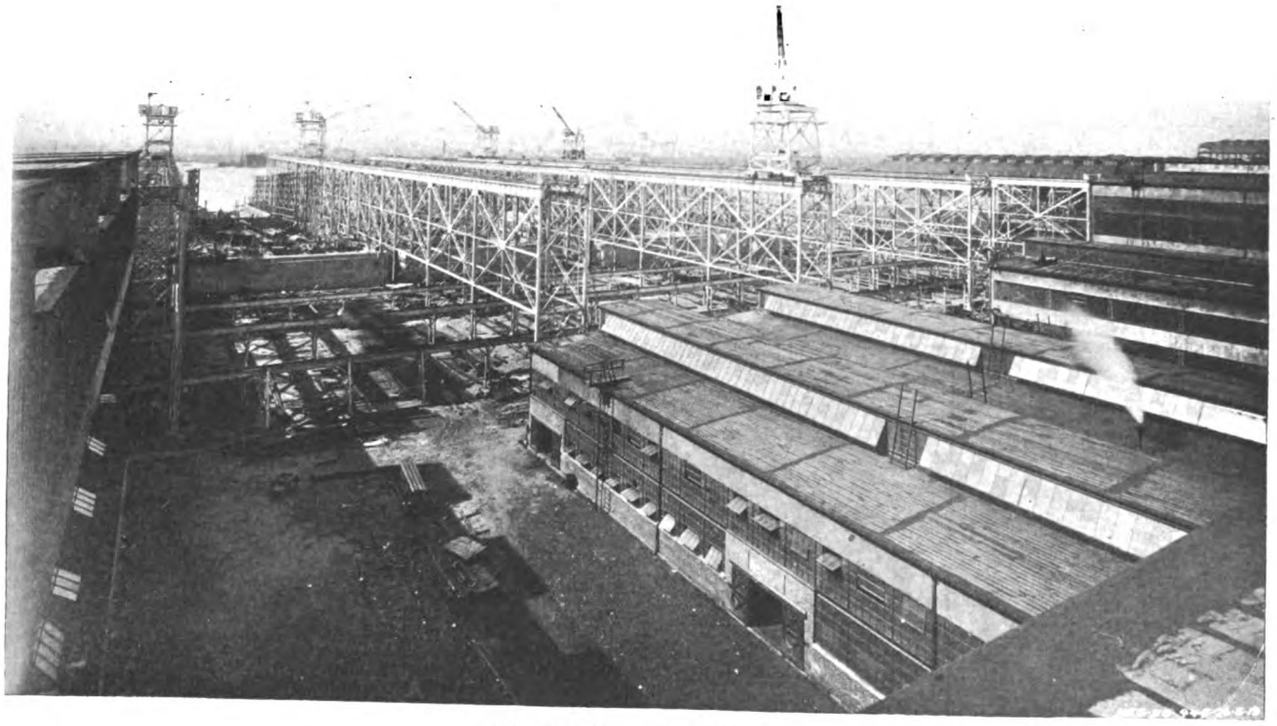
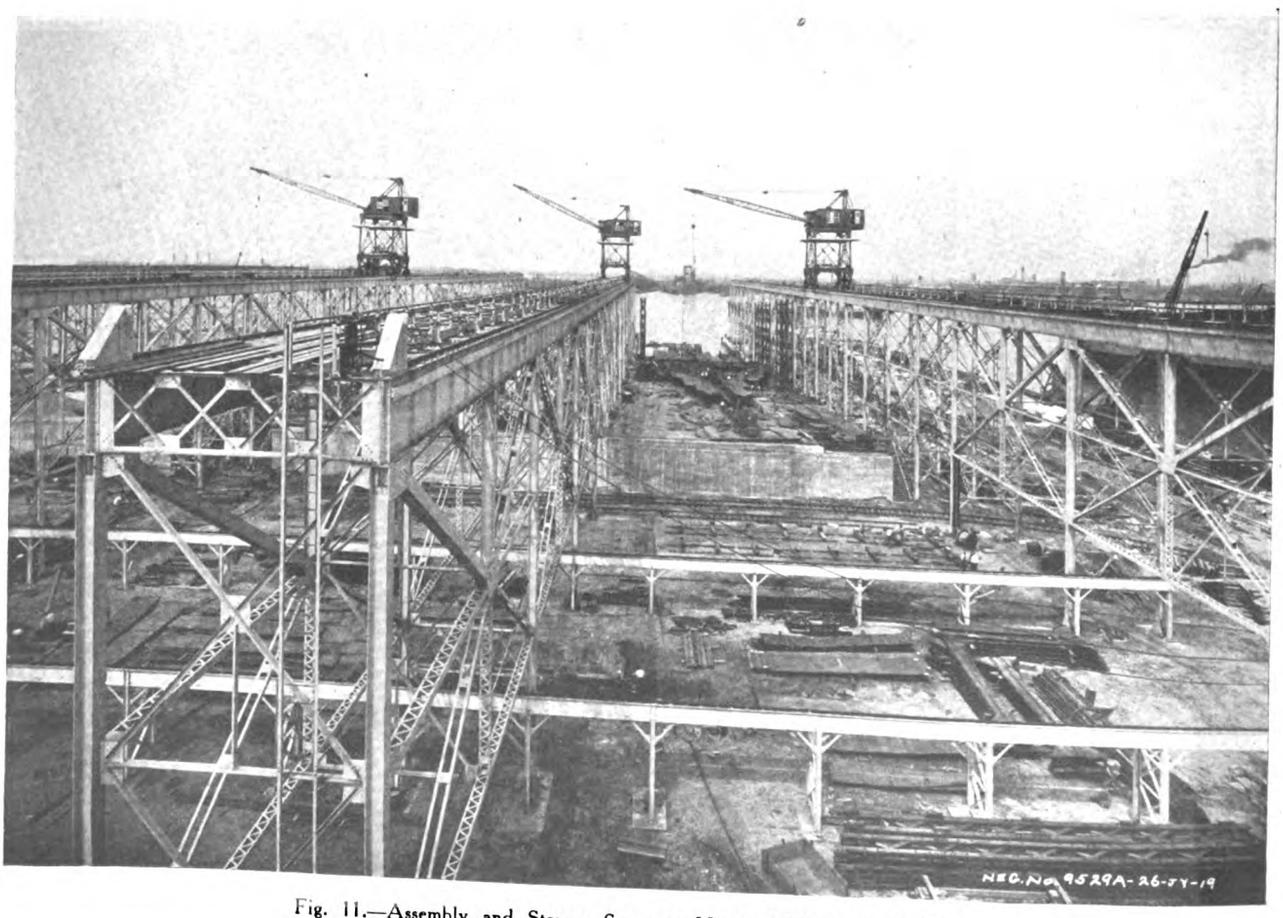


Fig. 10.—Ways, South Yard



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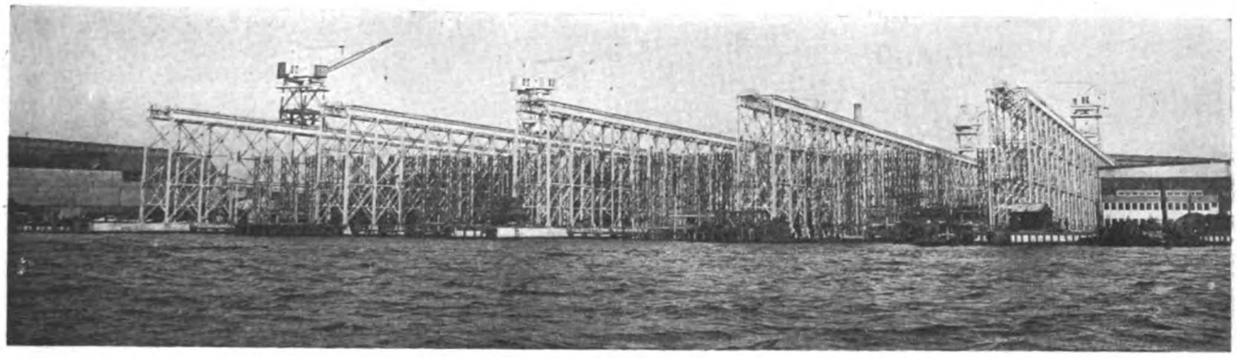

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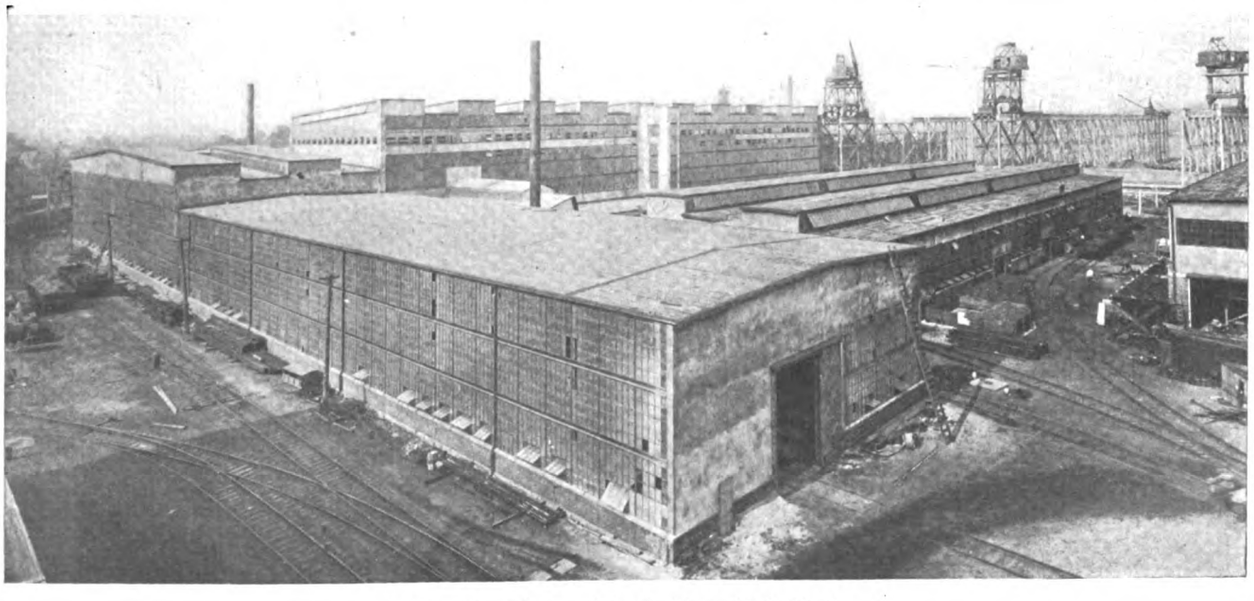

Fig. 13.—Plate and Angle Shop, South Yard

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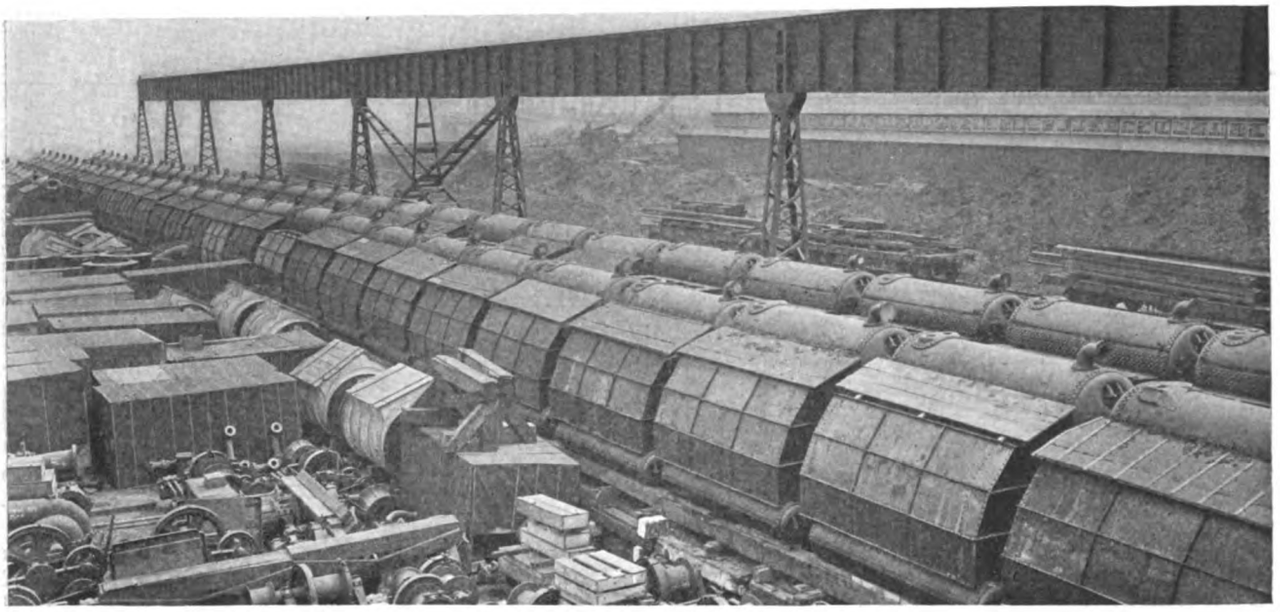

Fig. 14.—Watertube Boilers to Be Installed on Destroyers

which started on October 17, 1917. This project consisted of four open ways and six inclosed ways. The pile driving for foundation work was done by the Armstrong and Latta Company, Philadelphia. On the open ways material is handled by means of gantry whirler cranes supplied by the Dravo-Doyle Company, Pittsburgh. The covered ways are inclosed by a steel building in which are operated overhead traveling electric cranes. This building was erected by the American Bridge Company of New York on wood foundations consisting of piles capped with 12-inch by 12-inch square timber.

In addition to the ship ways, the destroyer plant included a plate and angle shop, 352 feet long by 282 feet wide; a power substation; a galvanizing plant, which,

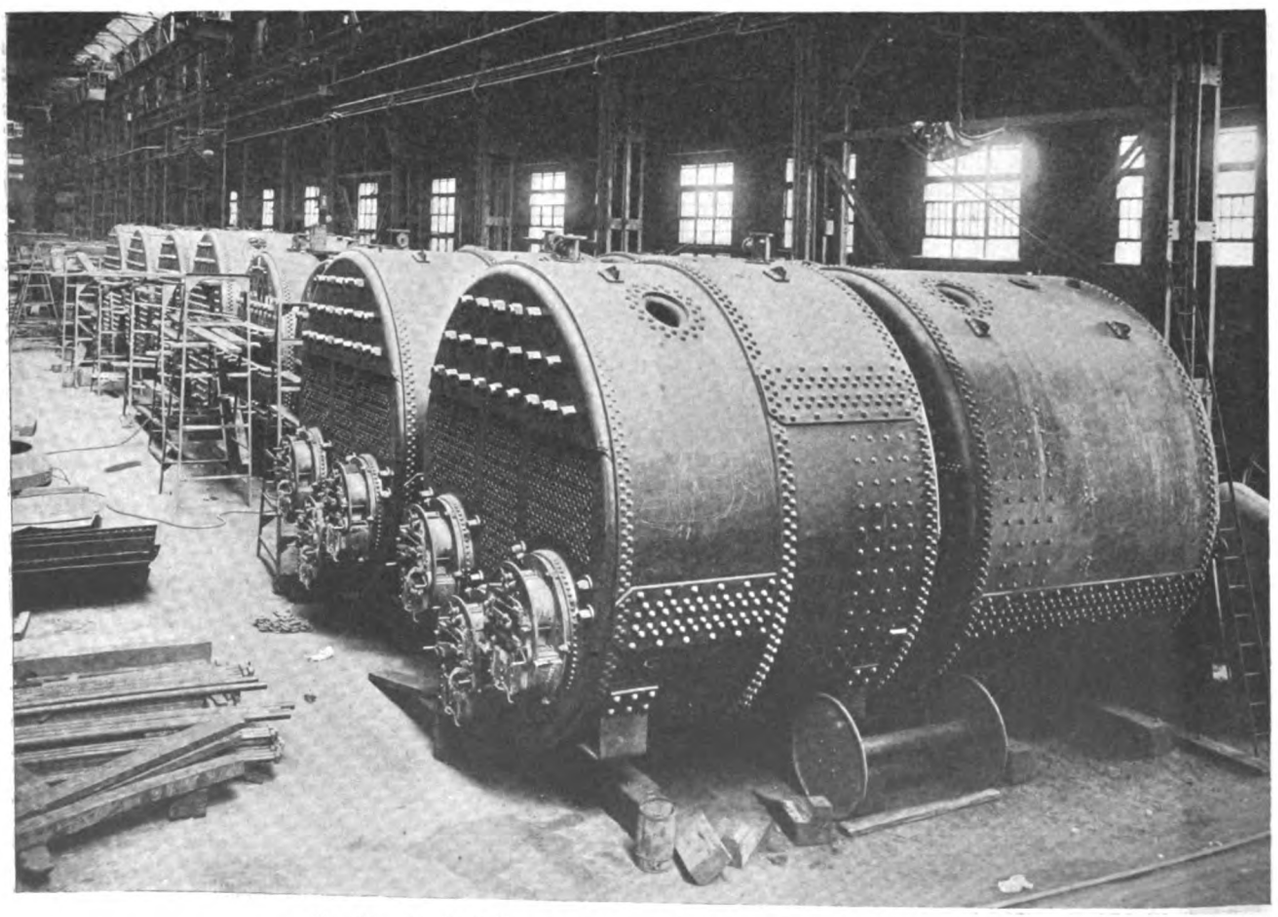

Fig. 15.—Scotch Boilers on Testing Floor, Boiler Shop, North Yard

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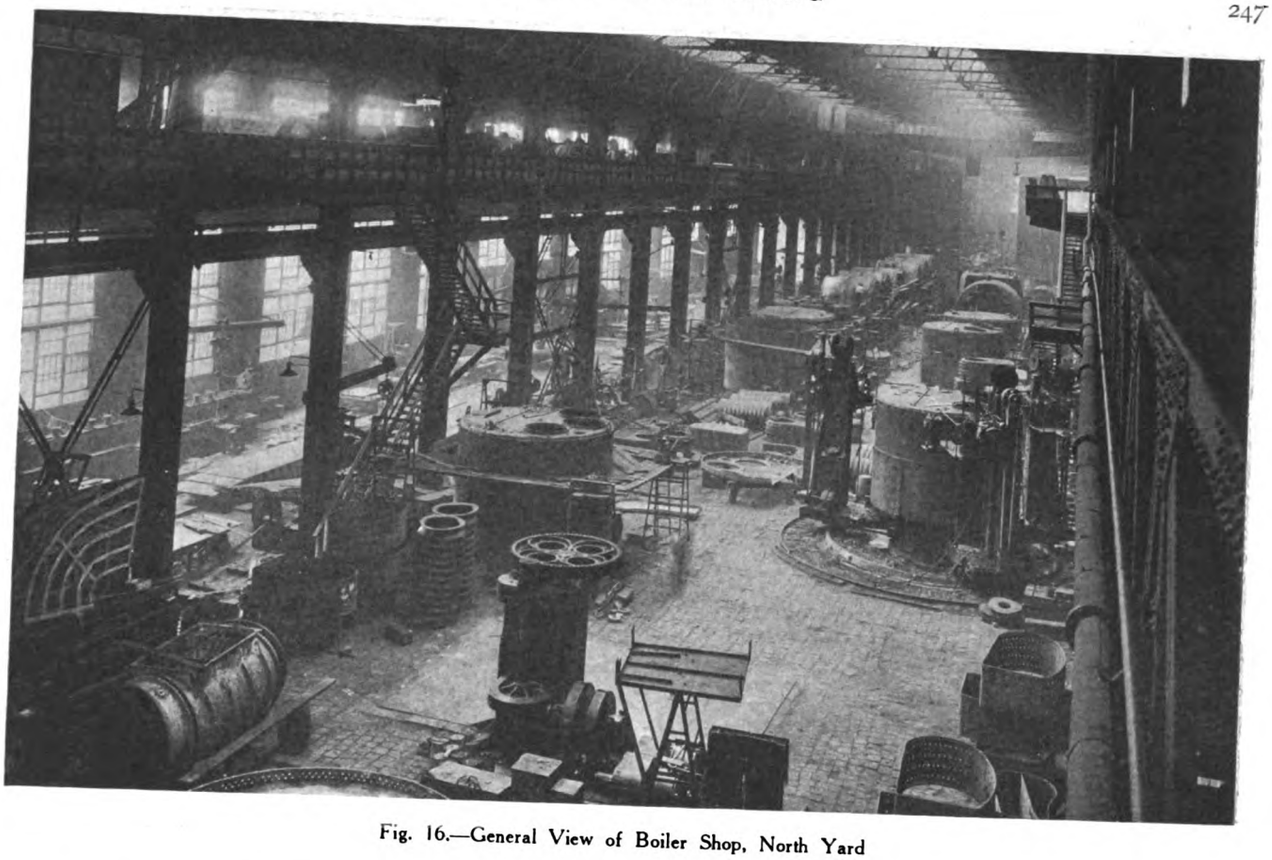

Fig. 16.—General View of Boiler Shop, North Yard

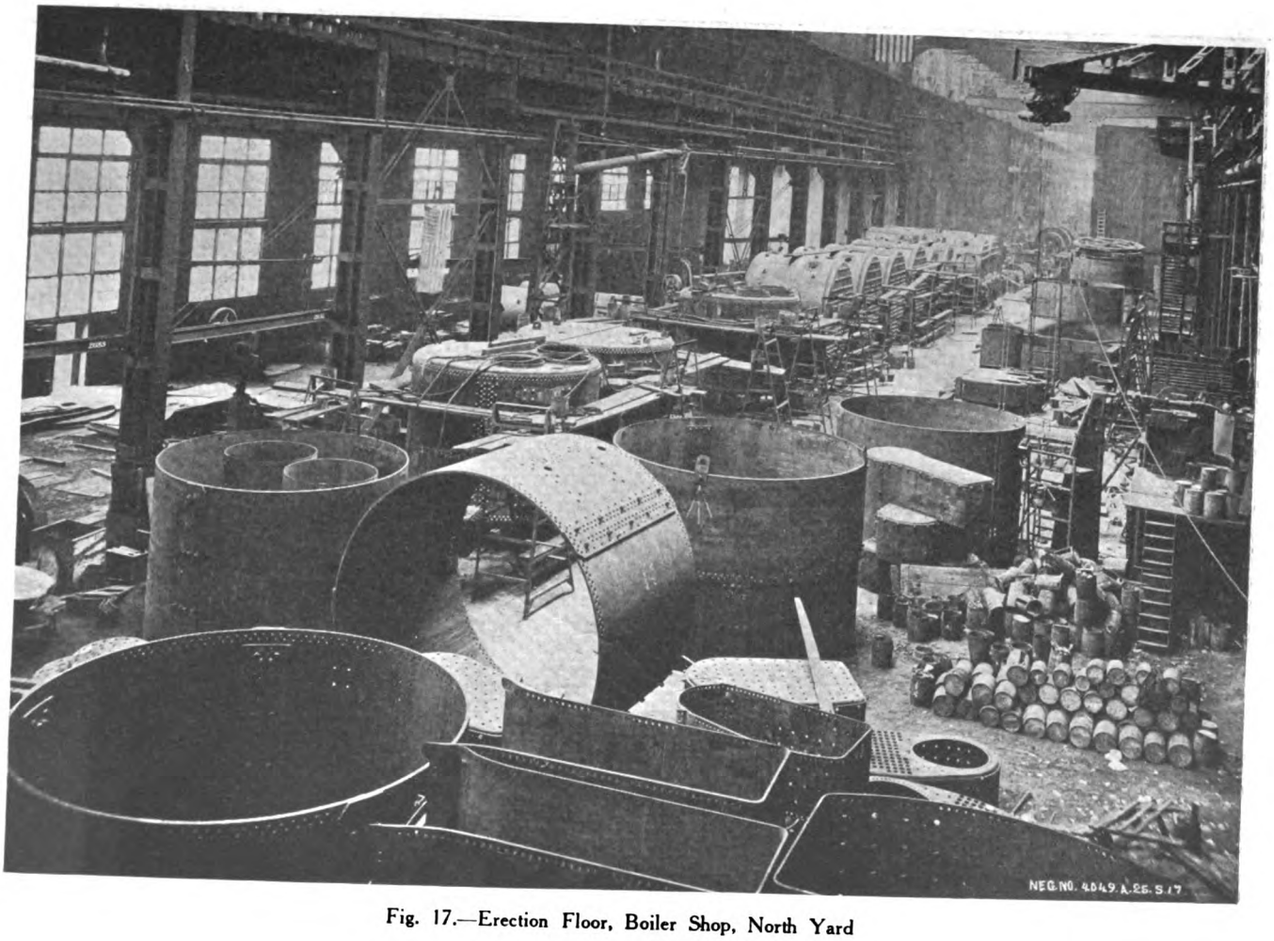

Fig. 17.—Erection Floor, Boiler Shop, North Yard

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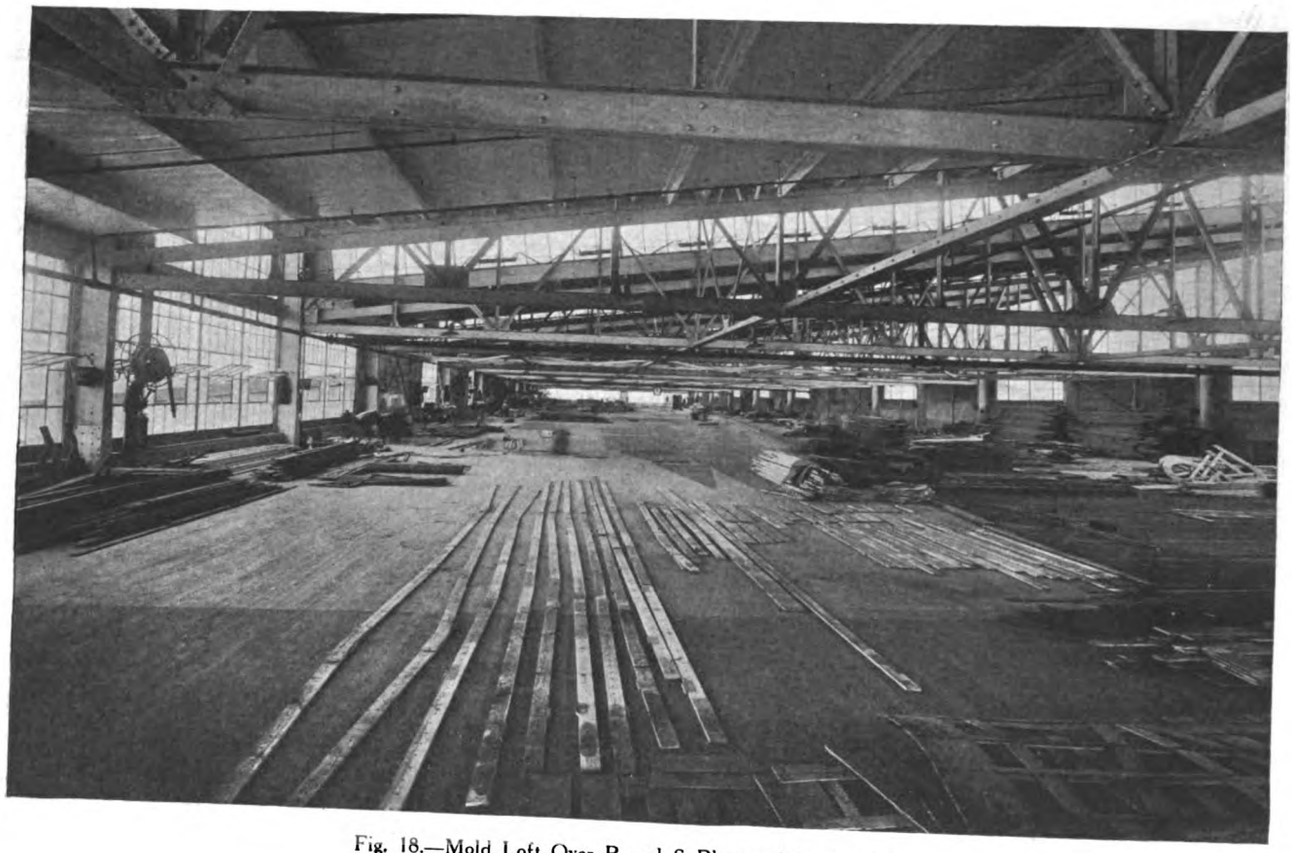

Fig. 18.—Mold Loft Over R and S Plate and Angle Shop

Fig. 19.—Plate Storage, R and S Plate and Angle Shop

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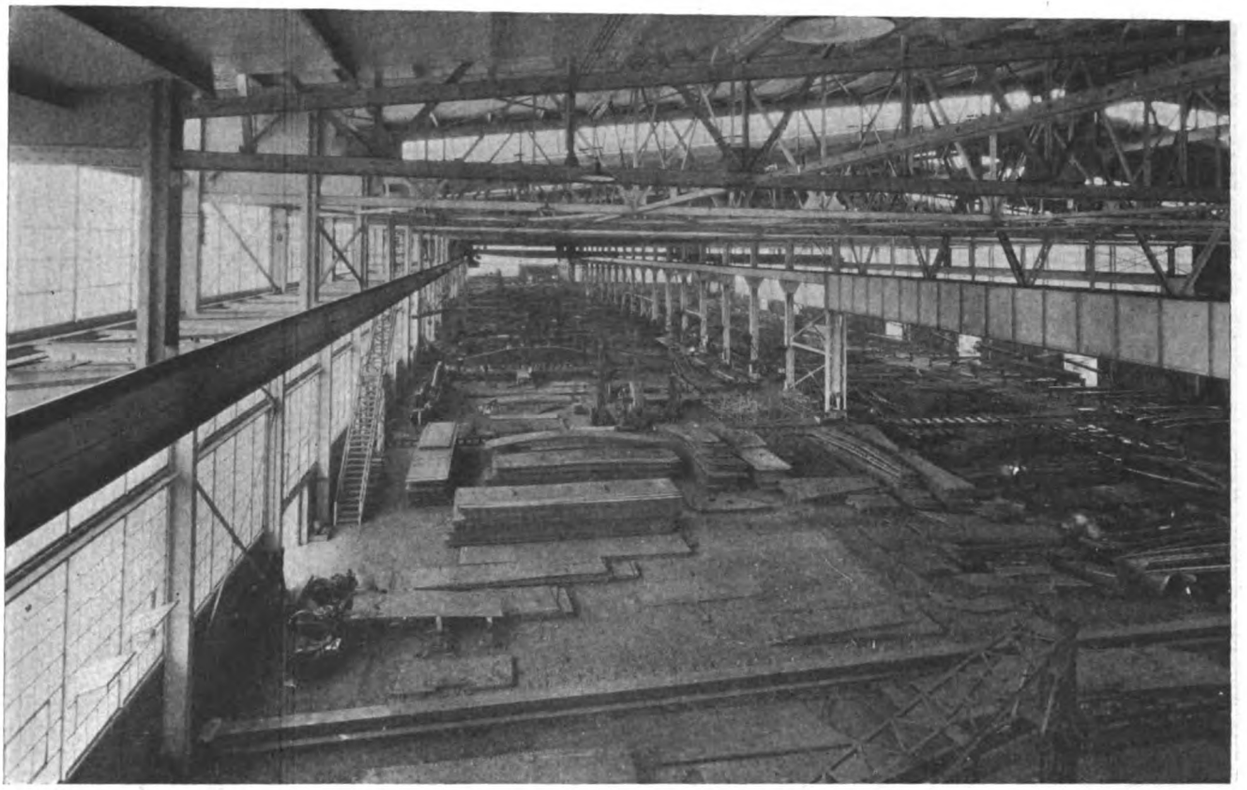

Fig. 20.—General View, Interior of R and S Plate and Angle Shop

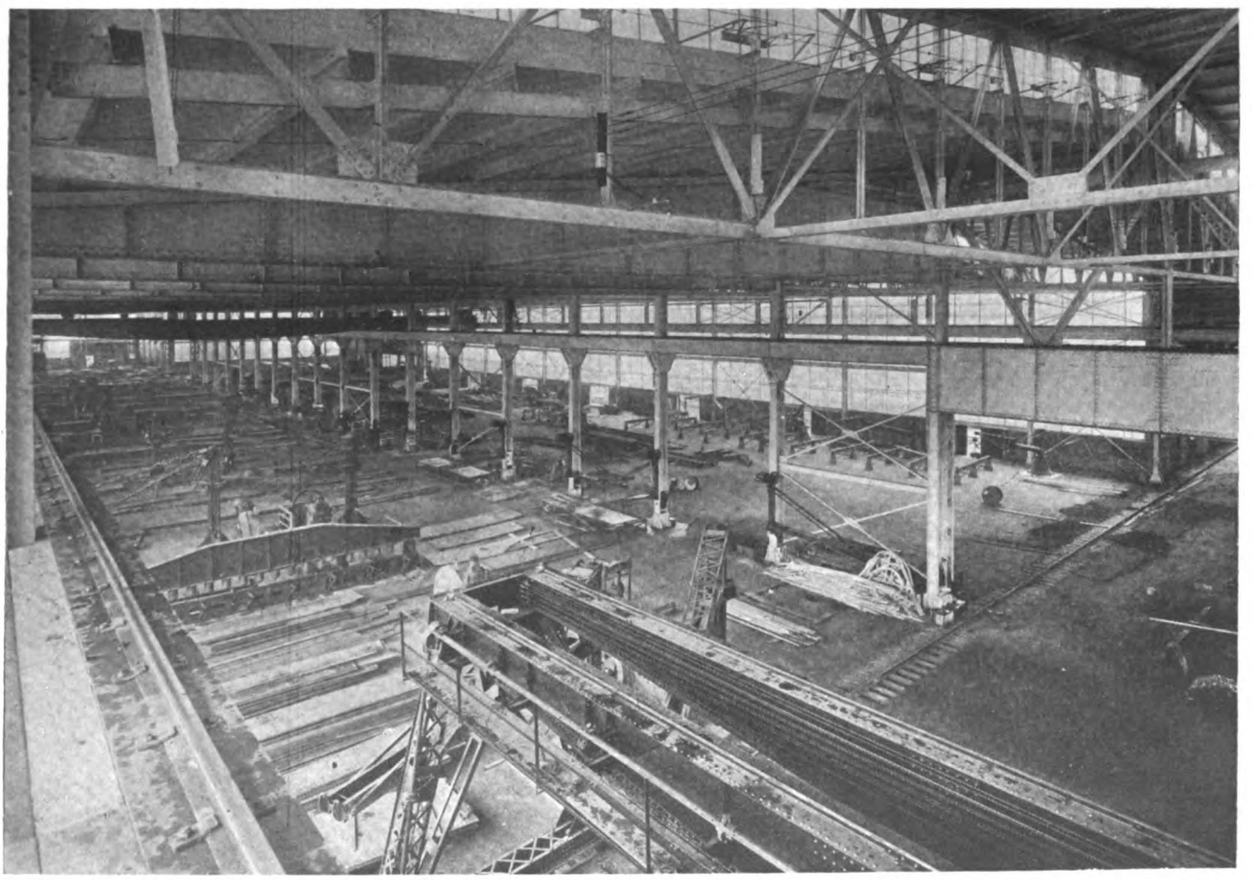

Fig. 21.—Center Section, R and S Plate and Angle Shop

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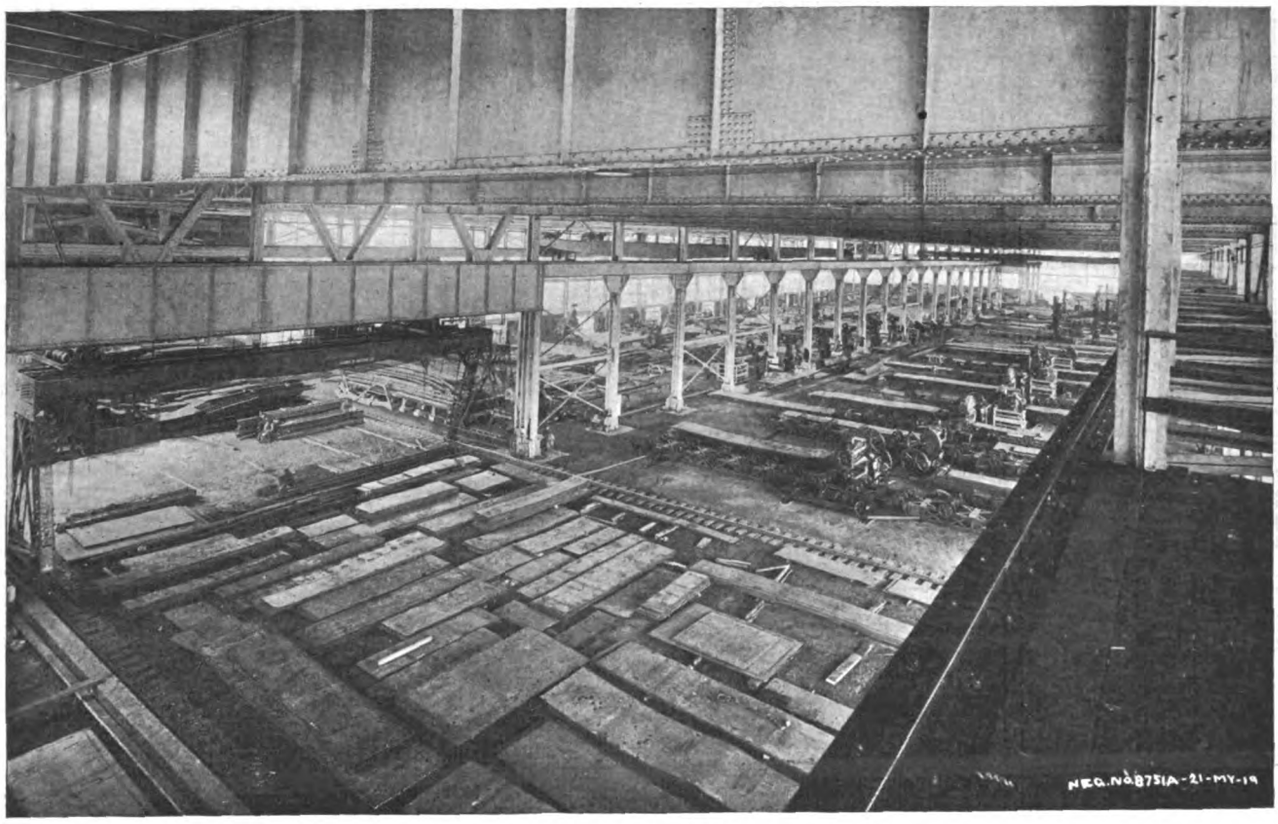

Fig. 22.—South End of R and S Plate and Angle Shop

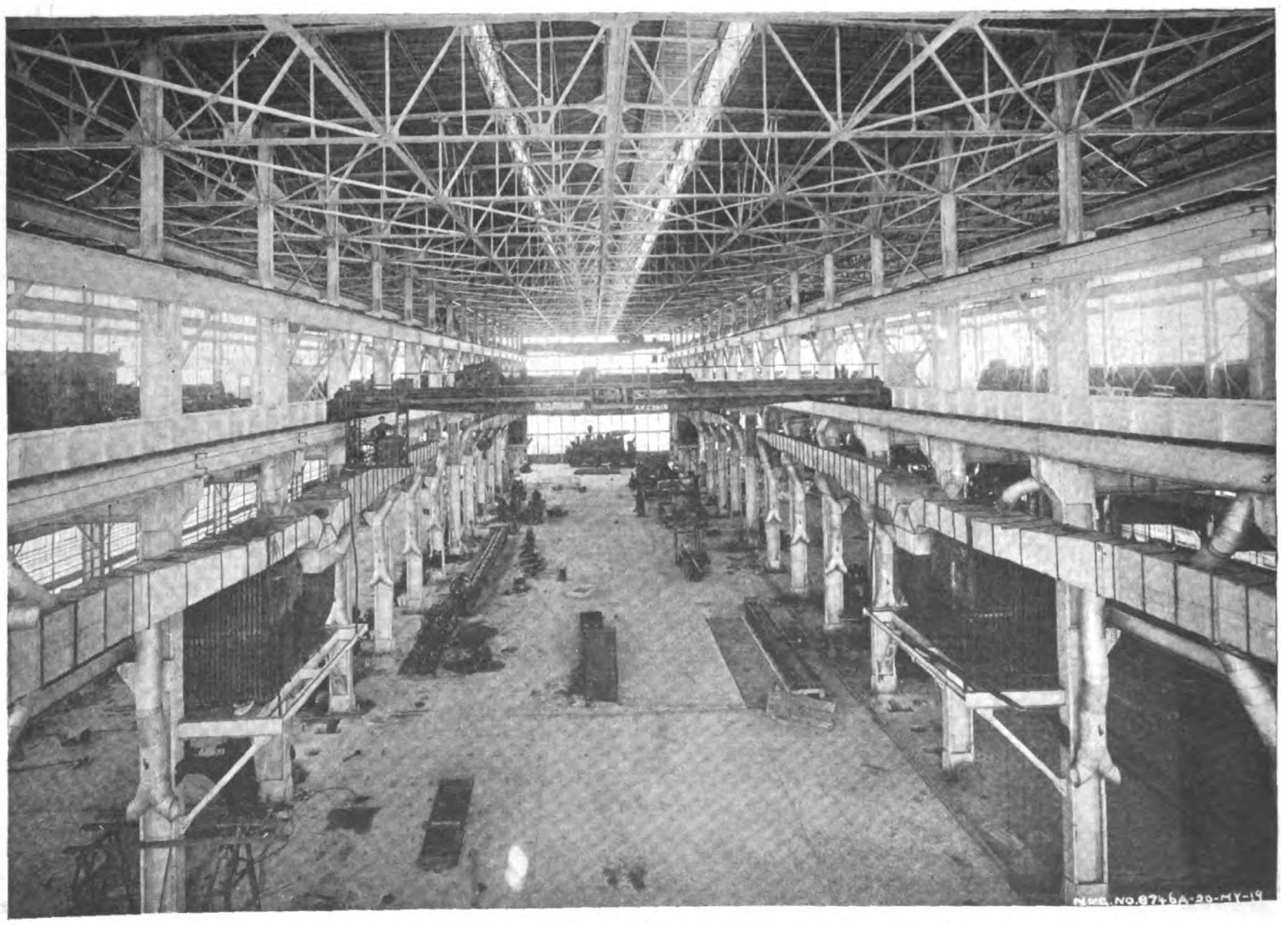

Fig. 23.—Interior View of Machine Shop, South Yard, Before Completion

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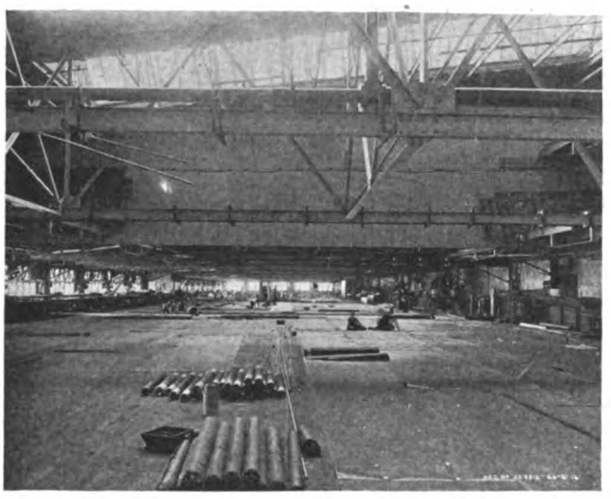

Fig. 24.—Mold Loft, North Yard

Fig. 25.—Interior Pipe Shop

incidentally, contains some of the largest galvanizing tanks in this country; a paint shop; a tool and office building and a storage house, 416 feet long by 64 feet wide, all built on land filled in by hydraulic dredging from Newton Creek at the south side of the yard. The dredging was carried out by the American Dredging Company. The plate and angle shop, tool and office building, power substation and storage house were built by the Holbrook, Cabot and Rollins Company, New York, of slow-burning timber construction. The galvanizing plant was built by J. S. Rogers, of Philadelphia, on foundations placed by Frazer, Brace and Company, New York, who also installed the concrete pits for the galvanizing tanks.

This project was built during the winter of 1917 and 1918, the most severe winter in the history of this location, and, on December 1, 1917, two of the open ways were ready for keels. The entire work was finished in April, 1918.

South Yard Extension

At this time the need of merchant ships became especially urgent and the Government adopted the policy suggested by Charles M. Schwab, at that time Director-General of the Emergency Fleet Corporation, of expanding where possible the old-established shipyards rather than attempting to build entirely new yards, the efficiency of which might be problematical. In line with this policy, the land owned by the New York Shipbuilding Corpora-

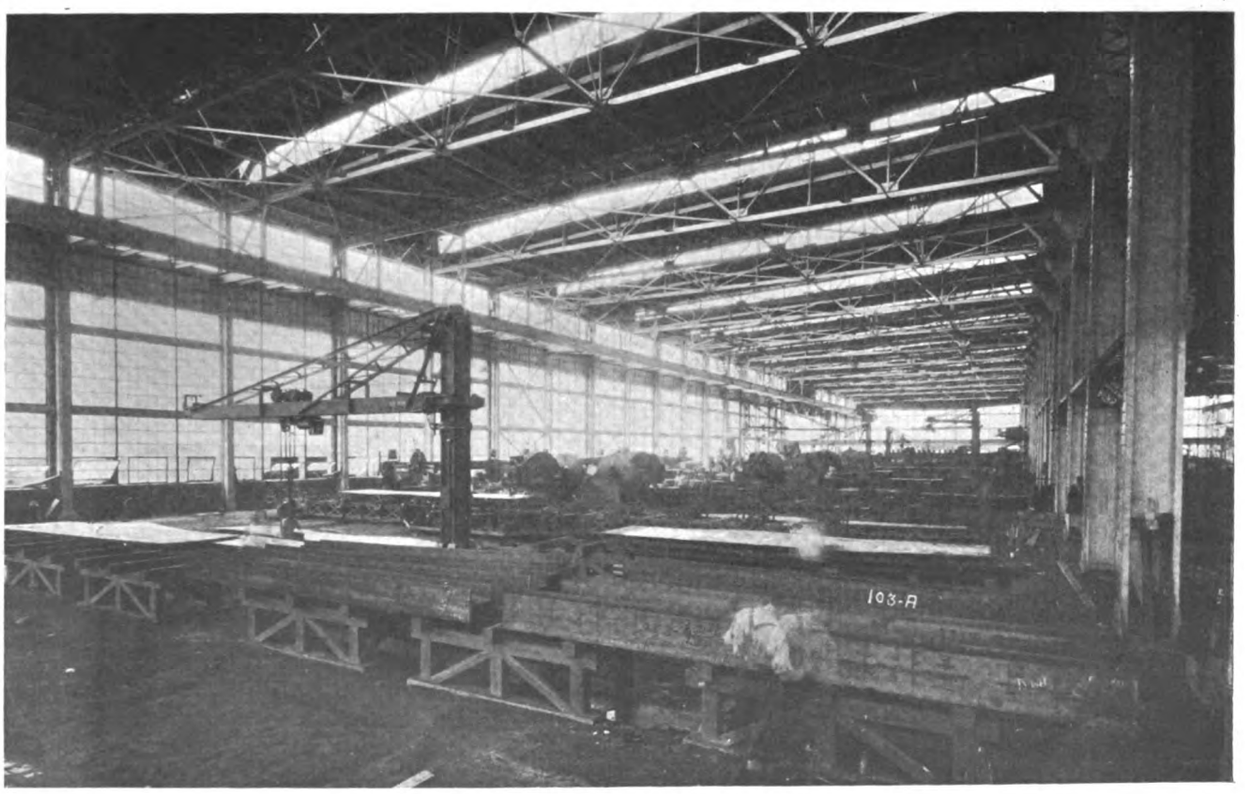

Fig. 26.—Plate and Angle Shop, South Yard

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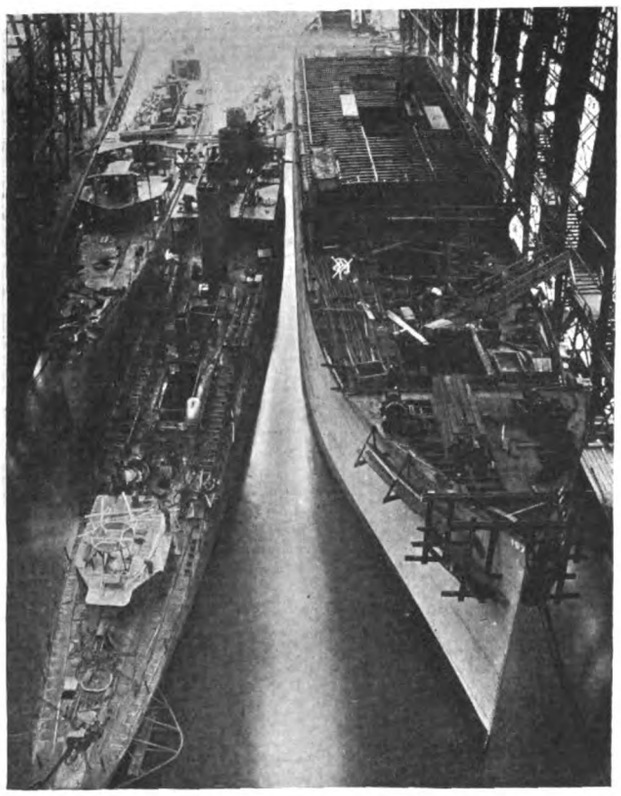

Fig. 27.—Wet Dock

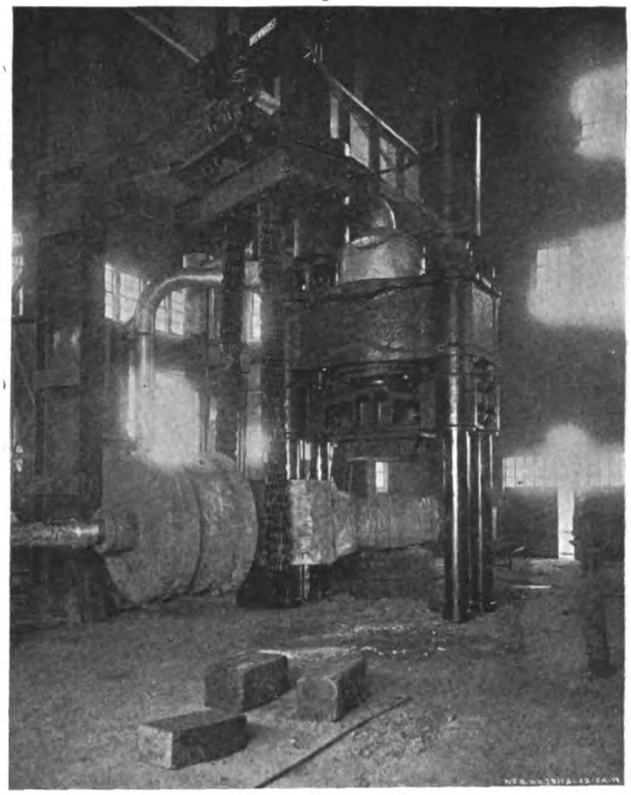

Fig. 29.—1,200-Ton Press in Forge Shop

tion, south of Newton Creek, was chosen as a site for the south yard extension. This south yard project included not only the building of the yard south of Newton Creek and west of Broadway, but also the development of all the land between Broadway on the west, the Atlantic City railroad and the Pennsylvania railroad on the east, Market street, Camden, on the north and Passaic street, Gloucester, on the south, all of which was below the elevation of high water.

Ideas for further expansion consummated in the planning of buildings *R* and *S*, which consist of a plate shop with a mold loft on the second floor, an angle shop and a steel storage building, all under one roof, being 792 feet long by 270 feet wide—probably the largest building in the country devoted to this character of work. The construction of buildings *R* and *S* started late in July, 1918, the piles for the foundation being driven by the Raymond Concrete Pile Company. Steel work on this building, amounting to approximately 3,500 tons, was fabricated by the L. F. Shoemaker Company, Pottstown, Pa., and erected by them on foundations prepared by Frazer, Brace and Company, New York. As shown by the illustrations, the walls of the building were practically of glass, the steel sash for which was manufactured and erected by the Truscon Steel Company. The stucco siding of the building was placed by Frazer, Brace and Company. The building was completed in March, 1919, and immediately put into operation. The equipment of the plant is very elaborate, the material being handled by overhead trav-

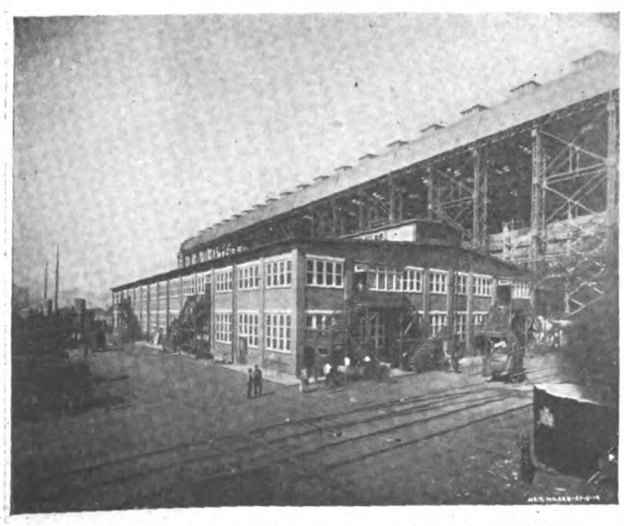

Fig. 28.—Lunch and Locker Building, North Yard

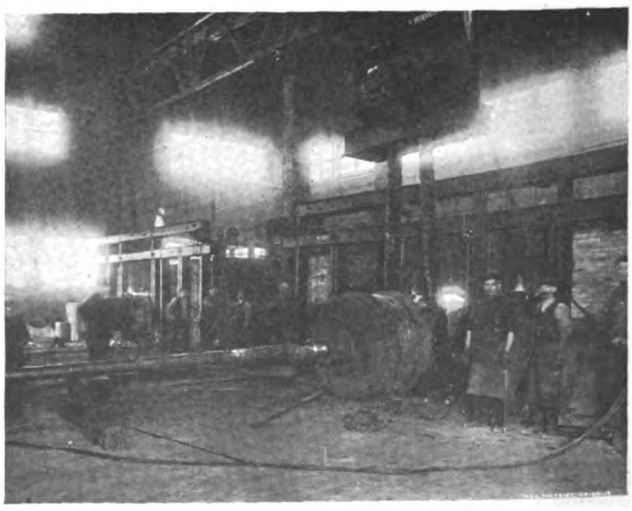

Fig. 30.—Furnaces for 1,200-Ton Press in Forge Shop

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Fig. 31.—Extension of Machine Shop, North Yard

Fig. 32.—Main Floor of Machine Shop, North Yard

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eling cranes and by heavy gantry cranes in the assembling sheds.

THE SOUTH YARD

The South Yard was constructed originally for the Emergency Fleet Corporation, but since the end of the war has been taken over by the New York Shipbuilding Corporation and now forms an integral part of its plant. Construction of the South Yard began in June, 1918, a line of piles being driven on pier 7 by the Armstrong & Latta Company to form a sheet pile fence to retain the sand fill pumped from Newton Creek. Wooden piles were driven on piers 7 and 8 under the column foundations of the ship runways and in the water end of the shipways proper, extending from the mean high-water mark to the extreme outboard end of the underwater section of the ways. Over a total length of 1,600,000 linear feet 30,000 piles were driven.

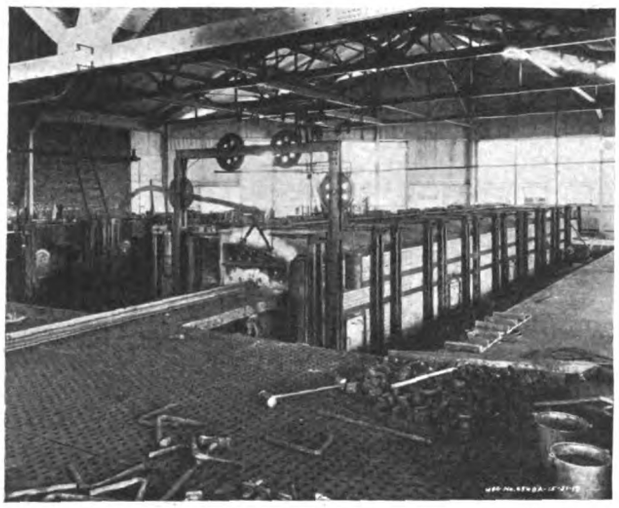

Fig. 33.—Furnaces in Plate and Angle Shop, South Yard

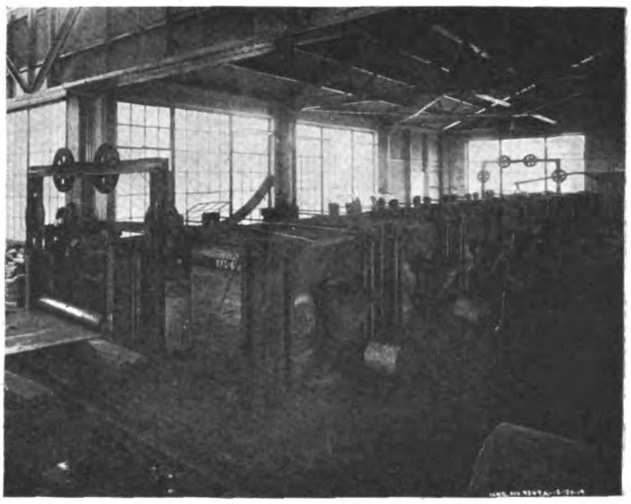

Fig. 34.—Angle Furnace, South Yard, Showing Underfeed Stokers

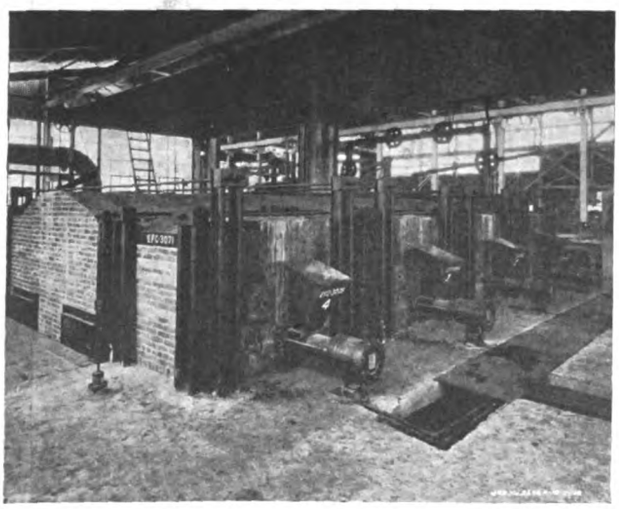

Fig. 35.—Coal-Fired Plate Furnace, South Yard

Fig. 36.—Copper Shop, South Yard

Both wet and dry fill were used in preparing the site for the building of the yard. A portion of the dry fill came from a hill at the extreme south end of the yard, which was removed, supplying 100,000 cubic yards of material. The wet fill was placed by the American Dredging Company, of Philadelphia, which began operations on July 1, 1918, by filling in the low land north of Newton Creek. The land east of Broadway was developed principally as storage yards; the section between the Atlantic City railroad and Passaic street being used as steel storage for the South Yard, the section north of the Atlantic City railroad to Newton Creek as coal storage, and the section north of Newton Creek as steel storage for the North Yard. The latter storage yard is provided with a crane runway carrying an overhead electric crane of 80 tons capacity. The hydraulic fill placed in the entire South Yard project amounted to 540,000 cubic yards of material.

The layout of the South Yard is plainly shown on the plan, Fig. 4, the plant consisting of four sets of shipways each 103 feet wide and 600 feet long. At the head of the ways are three wide bays served by railway tracks and overhead cranes connecting with the plate and angle shops on the side and the machine shop, the blacksmith shop and other buildings in the rear. A feature of the construction of the building ways in the South Yard is the carrying out of the idea first used on ways *T* and *U*, as previously explained, of placing concrete sills in the hydraulic sand fill extending from the head of the ways down to the high-water mark. Although this is a radical departure from the methods of constructing shipways used in the original yard, nevertheless the concrete sills have been subjected to careful observation and have proved entirely satisfactory.

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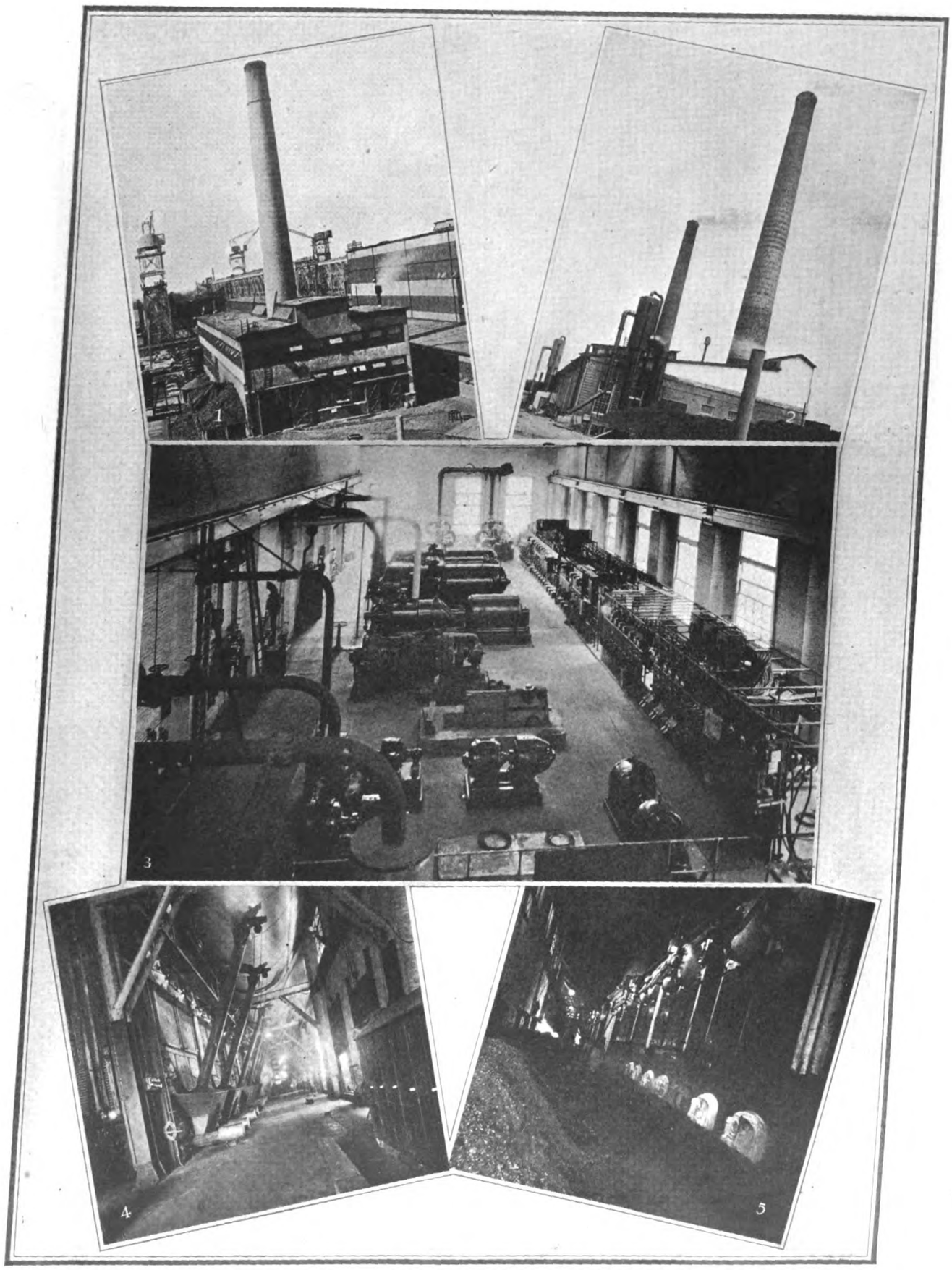

Fig. 37.—Views of Power Plant. (1) Power House, South Yard; (2) Power House, North Yard; (3) Interior of Main Power House, North Yard; (4) Boiler Room, North Yard, Showing New Equipment of Mechanical Stokers; (5) Boiler Room, North Yard, Before New Equipment Was Added

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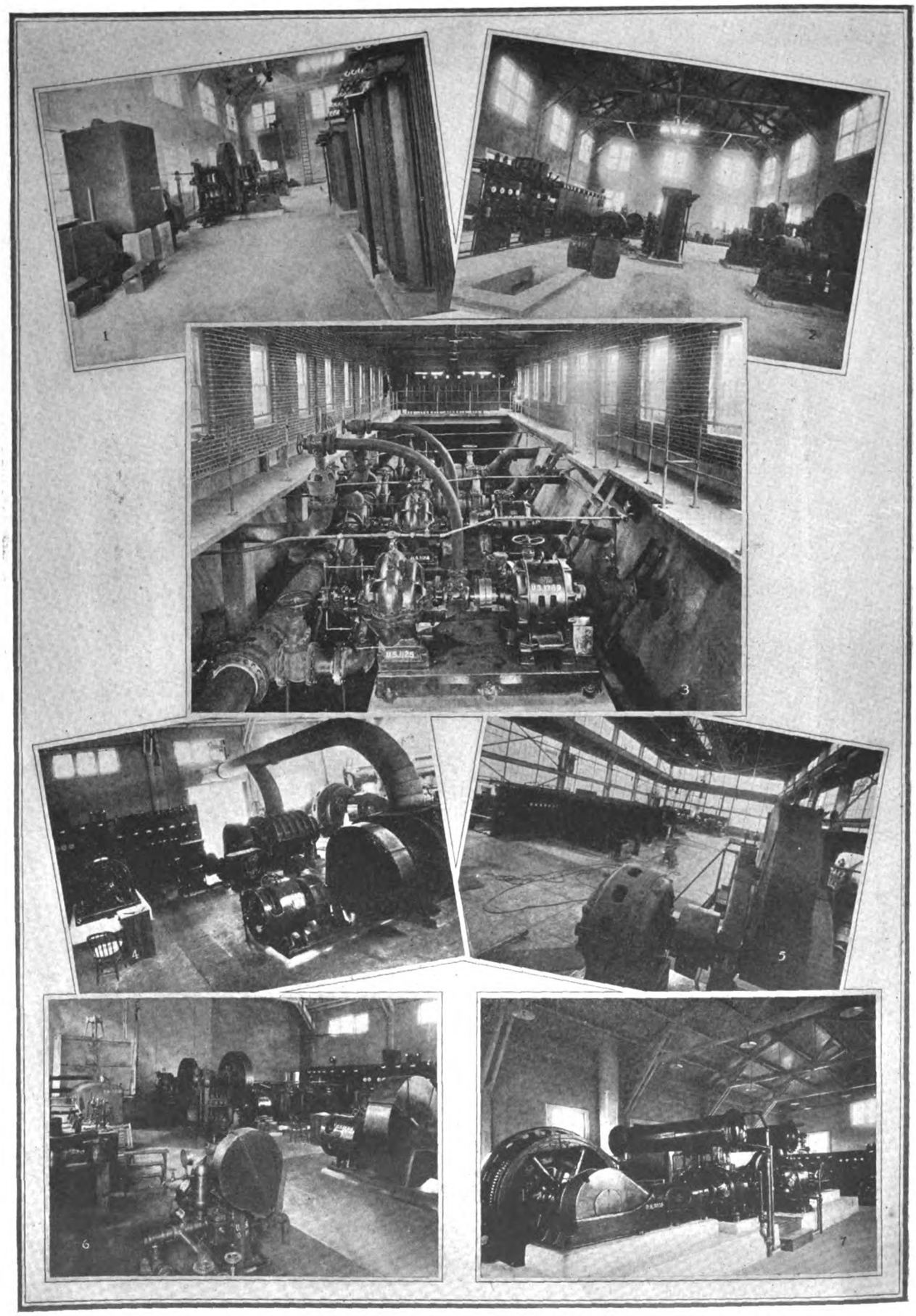

Fig. 38.—Views of Power Plant. (1) R and S Sub-Station; (2) T and U Sub-Station; (3) Interior of Pump House at T and U Ways; (4) Sub-Station; (5) Interior of Power House, South Yard; (6) Interior of Power House, Destroyer Ways; (7) Air Compressors in T and U Sub-Station

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The superstructure on the ways at the South Yards is of steel, fabricated by the McClintic Marshall Company, Pittsburgh, Pa., and erected by them. At each runway there is a Brownhoist gantry whirler, tested for lifting a load of 45 tons at a 20-foot radius.

The first permanent building started in the South Yard was the plate and angle shop, the foundations for which were placed by the Hugh Nawn Contracting Company,

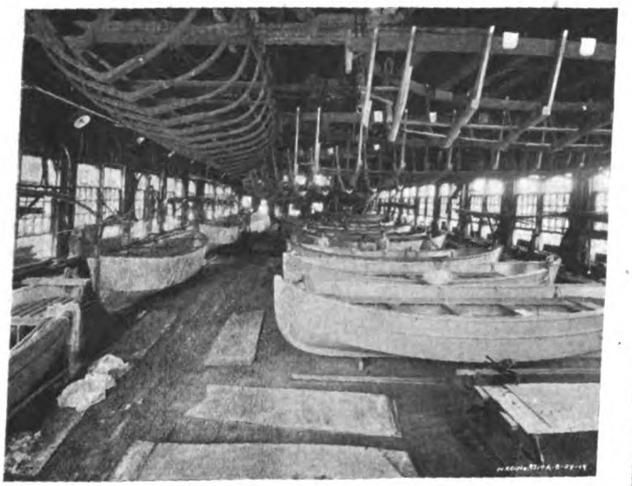

Fig. 39.—Small Boat Shop, South Yard

Boston, Mass., in July, 1918. Shortly afterward the freight house foundations were started by the Raymond Concrete Pile Company, and then the blacksmith shop was started, the Raymond Concrete Pile Company driving the piles and the foundations being placed by the Hugh Nawn Contracting Company. The power house, copper shop and machine shop were started in the order named, and following these the administration building and carpenter shop were constructed on the east side of Broadway. In the entire project 5,300 concrete piles were driven. The shops in the South Yard are elaborately equipped with machine tools, overhead cranes, etc. Two 15-ton cranes serve the plate storage yard alongside the plate shop, six overhead cranes were installed in the plate and angle shop, and seven in the machine shop, one of 50 tons capacity, one of 20 tons, one of 15 tons and four of 10 tons capacity.

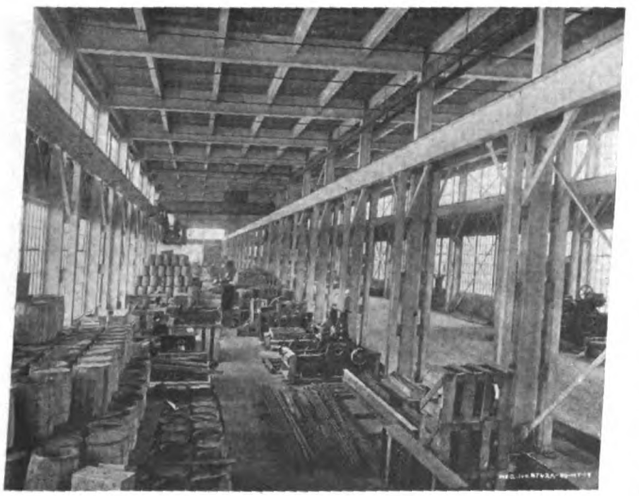

Fig. 40.—Freight House, South Yard

In the construction of the South Yard all concrete spread foot foundations and all foundations of Raymond concrete pile were placed by the Hugh Nawn Contracting Company and all foundations of wood piles were placed by the Armstrong & Latta Company. All steel for the buildings and runways, amounting to 10,000 tons, was fabricated and erected by the McClintic Marshall Company of Pittsburgh. The roof coverings of the buildings were placed by the Benjamin Foster Company, of Philadelphia. The steel sash was constructed and erected by the Truscon Steel Company, Youngstown, Ohio.

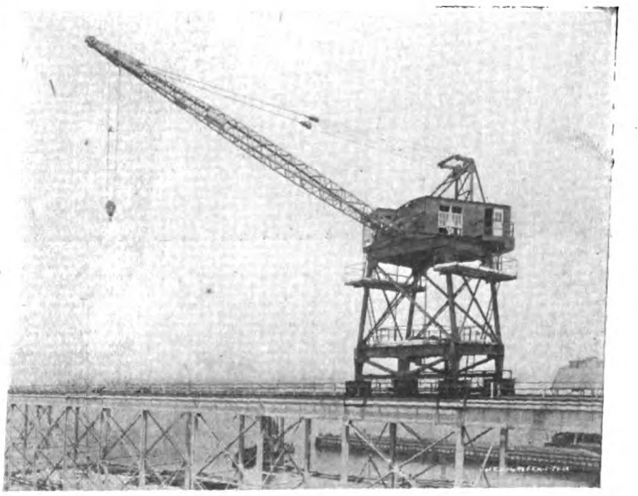

Fig. 41.—Brownhoist Crane on Ways, South Yard

A feature of the building construction was the use of the cement gun in placing stucco siding on the buildings. In all, 12,000 square yards of stucco were placed by the Dewey Cement Company, of Allentown, Pa.

The yard was completed on August 31, 1919, long before which all of the shops were in operation, fabricating, and manufacturing ship material and ships were under construction on every set of shipways. The first keel in the South Yard was laid early in May, 1919. About 3,000 men are employed in the South Yard.

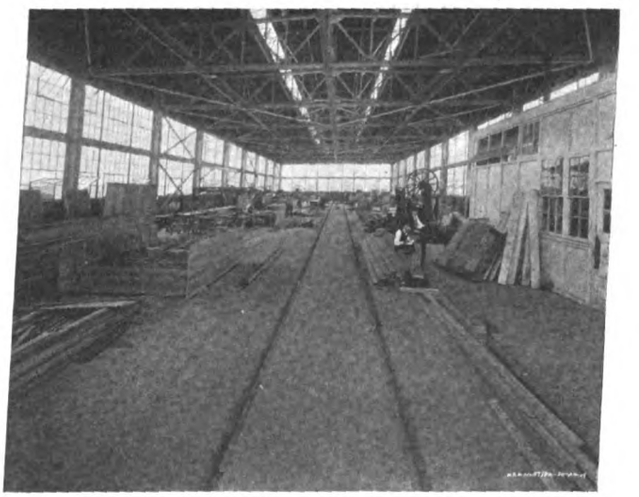

Fig. 42.—Carpenter Shop, South Yard

Power Plant

Power for the entire shipyard is generated in two power plants, one in the North Yard and the other in the South

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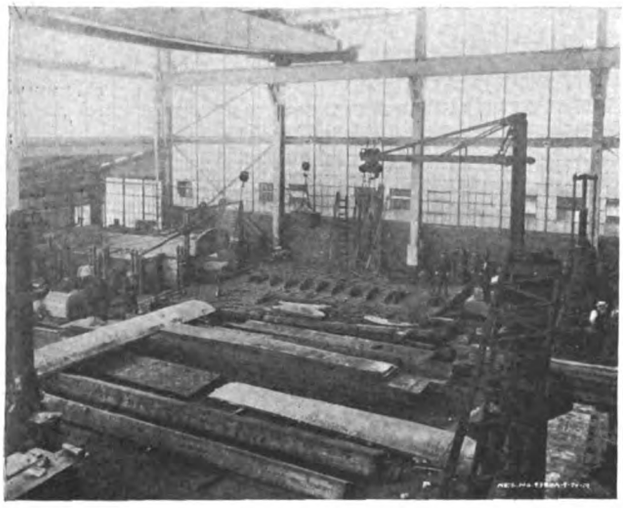

Fig. 43.—R. & S. Plate and Angle Furnaces

Fig. 44.—Lunch and Locker Building. Men Waiting to Be Served

Yard. Plans for enlarging and increasing the power plant were worked out by F. F. Kauffmann, mechanical engineer of the plant, to whom we are indebted for the following information:

In 1916 the main power plant in the North Yard was equipped with the following: Six Altman-Taylor water-tube boilers, rated at 266½ horsepower each and four Babcock and Wilcox boilers with the same rating, all built for 165 pounds working steam pressure and connected to a radial brick stack 11 feet inside diameter at the base, 8 feet 6 inches inside diameter at the top and 204 feet high. These boilers supply steam to two Ingersoll-Rand two-stage air compressors each with a capacity of 4,000 cubic feet of free air per minute at 100 pounds pressure; also one Ingersoll-Rand two-stage cross-compound air compressor of 3,200 cubic feet capacity at 100 pounds per square inch pressure.

The electrical generating units consisted of three 500 kilowatt direct-connected Westinghouse machines, two of which are of special design. One machine supplies both direct and alternating current at 240 volts. The third unit is a straight direct current machine of the same voltage. The above units are all piped up and arranged so that they can exhaust through a Bayer barometric condenser carrying 27 inches vacuum or they may exhaust to the heating system or to the atmosphere, as required.

In addition to the above-named units, there are two duplex tandem compound hydraulic pumps supplying a pressure of 1,500 pounds per square inch throughout the plant, each pump having a capacity of 150 gallons per minute. There are also three underwriters' fire pumps of 1,500 gallons per minute capacity each at 100 pounds per square inch pressure and the usual feed pumps, service pumps, feed water heaters, etc.

The boilers mentioned above were all hand fired, using a high-grade bituminous coal with settings of a standard type, providing a height of 6 feet from the floor to the under side of the tubes. These boilers were all equipped with draft gages, pyrometers for measuring the temperature of the stack gases, CO_2 recorders and gas collectors. Tests conducted on the old plant, operated day and night, showed a current cost over the switchboard of .43 cent per kilowatt based on the cost of fuel only, the cost per 1,000 pounds of steam evaporated from and at 212 degrees Fahrenheit, averaging about 16 cents. This was, of

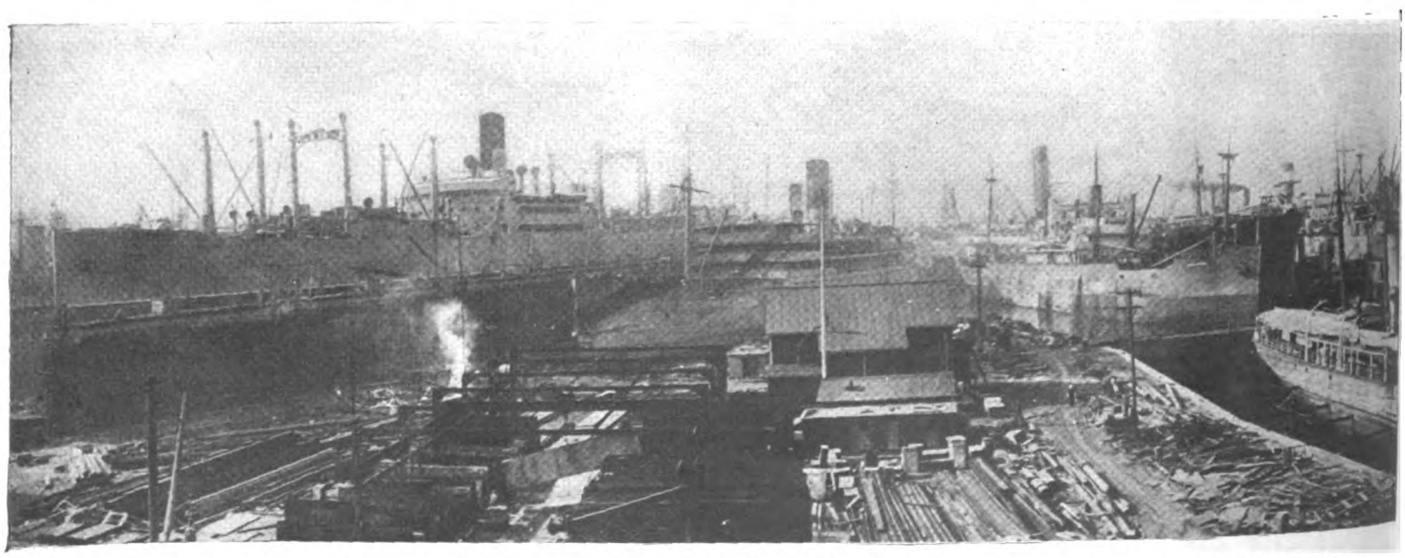

Fig. 1.—Section of Plant of Robins Dry Dock & Repair Company, Erie Basin, Brooklyn, N. Y. This is

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course, based on the price of fuel prevailing at that time and showed remarkable economy for hand-fired units of this type.

At the beginning of the war the load began to increase materially, and it was decided to build an extension to the power house rather than buy the current from the Public Service Corporation. This decision was based on the fact that 30 percent of the total steam generated in the plant was required for electric power, while the other 70 percent was required for the air compressors, for heating the buildings, for testing, for water supply and for the requirements of the very large forge shop, which was added to the plant at this time.

The additions made to the power plant will be described in our next issue.

For the information and data given in this article we are indebted to the following officials of the New York Shipbuilding Corporation: H. A. Magoun, senior vice-president; E. H. Rigg, naval architect; E. H. Sapp, civil engineer; D. C. Nevins, assistant civil engineer; F. F. Kauffmann, mechanical engineer, and S. G. Jenks, general superintendent (South Yard).

The World's Largest Ship Repair Company

MORE than 225,000,000 tons of shipping, steam and sail, harbor, coastwise and deep water, have been dry docked in the big repair yards owned by the Todd Shipyards Corporation in New York harbor and on the Pacific coast.

This stupendous total is more than four times the merchant tonnage of the world at the end of 1919. These 225,000,000 tons, representing vessels of every size and type, have been handled by the nineteen floating docks and the two graving docks that are distributed among the various Todd yards. Excluded from this remarkable dry docking record are the thousands of vessels—from chunky but essential tugs to the speediest ocean greyhound—on which work has been performed at piers and elsewhere, in the harbor by the skilled mechanics of the Todd Shipyards Corporation.

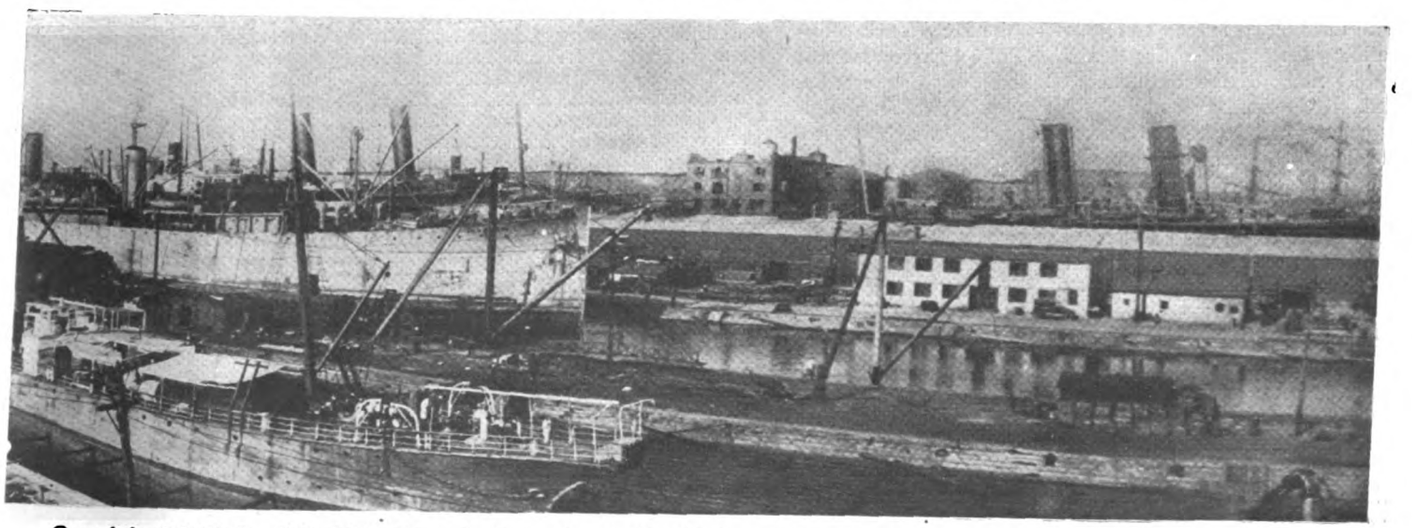
There is no other ship repair organization in the world operating as many dry docks as this American company. The Todd dry docks placed end to end would measure nearly a mile and a half, and if the vessels that have been on those docks were set stern to bow they would span the continent from Erie Basin to Puget Sound.

It seems appropriate at this time—the renaissance of American shipping—to cite the foregoing figures in the belief that they will convey some idea of the ship repair facilities of the world's largest ship repair organization. A ship is a ship only when in service, and if a nation would possess a merchant marine it must have adequate facilities for the proper upkeep of the ships that fly its flag.

The Todd organization is a federation of expert men and great plants for united application of the best modern industrial practice to every kind of shipwork from construction to interior decoration. It is equipped to build any vessel, from ocean liner to river barge. It possesses unsurpassed facilities for remodelling, lengthening and refitting ships of any character and for any service. It has made world records in the handling of the biggest repair jobs that ever have been sent to American yards. Its resources include nine construction ways, two graving docks, nineteen floating dry docks, twenty-five piers, a fleet of tugs, floating derricks and service craft and the latest improvements in shop equipment.

Co-operation binds all the organizations, yards and plants of the corporation into one powerful whole which is at any moment capable of concentrated effort. In all other respects, however, each organization is an independent unit for itself, with its individual prestige to maintain. This makes for exceedingly sharp competition between them all for achievement, efficiency, speed and economy; but there is free interchange of knowledge and experience, mutual enjoyment of inventions and improvments and, when necessary, exchange of resources.

Each plant is not only a unit in itself, but the unit principle is so applied that every vessel obtains unit treatment precisely as if it were the only vessel in a yard devoted entirely to it. This concentrated individual attention is made possible by ample berthing spaces and dockage capacities, an abundance of experienced workers, and every modern facility for applying power in all its forms directly to every ship.



One of the Subsidiaries of the Todd Shipyards Corporation, the World's Largest Ship Repair Organization

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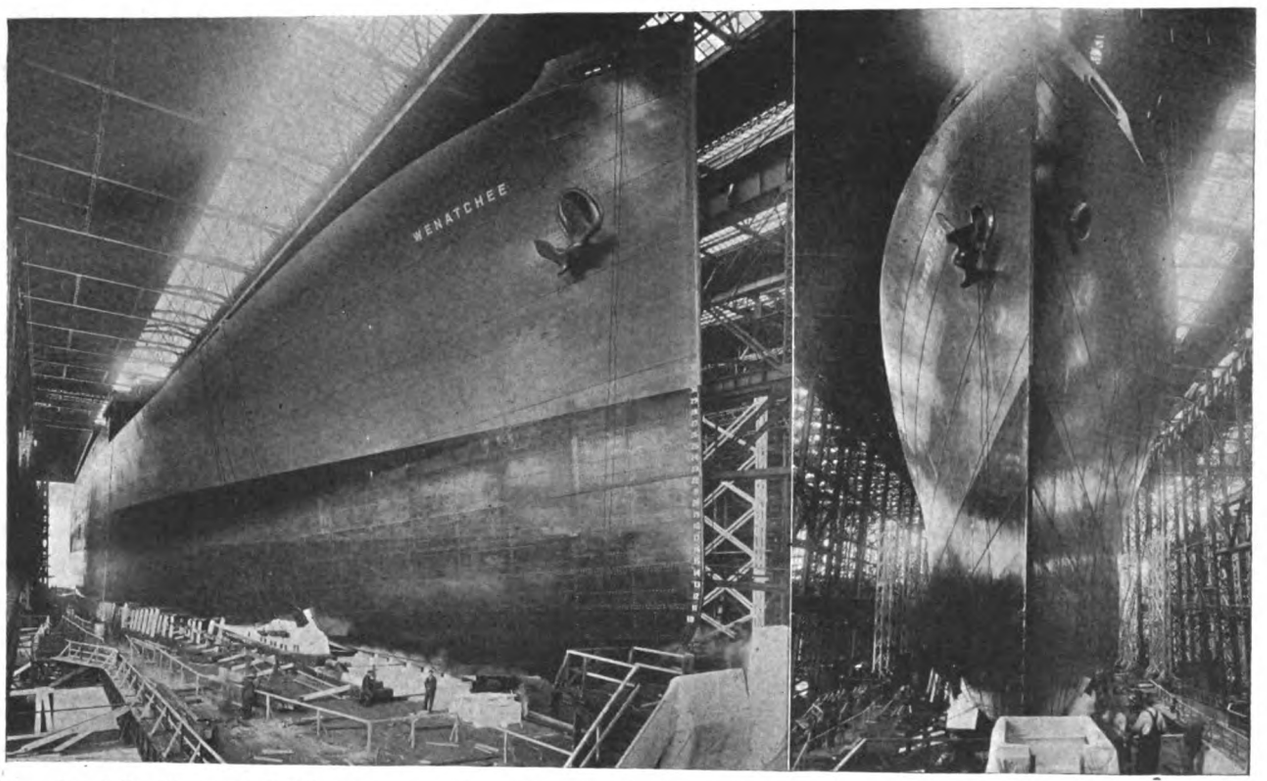

Figs. 1 and 2.—Views of 535-Foot Passenger Liner *Wenatchee* Ready for Launching at North Yard of New York Shipbuilding Corporation, Camden, N. J.

New American Passenger Steamers

Description of 17½-Knot, 535-Foot Passenger and Cargo Vessels Building for the Shipping Board—Gross Tonnage, 13,500

ONE of the most striking features of the huge shipbuilding program started by the United States Shipping Board during the war, and now nearing completion, is the fleet of large passenger and cargo steamships which were first laid down as troop ships, but which are now being fitted out for fast passenger and mail service. This fleet is composed of two types of vessels. In the first the vessels are 535 feet long of 13,500 gross tons and 17½ knots speed, and in the second 502 feet long between perpendiculars, of 10,500 gross tons and 14 knots speed.

Of the larger vessels, nineteen are now under construction, distributed among the yards of the New York Shipbuilding Corporation, Camden, N. J., the Sparrows Point (Md.) plant of the Bethlehem Shipbuilding Corporation, Ltd., Bethlehem, Pa., and the Newport News Shipbuilding and Dry Dock Company, Newport News, Va. According to the tentative plans of the Shipping Board for the development of passenger service from American ports, twelve of these vessels will be assigned to the following routes on the Pacific:

Weekly sailings to Japan, China and the Philippines.

Weekly sailings to Japan, China and Vladivostock.

Sailings every three weeks to the Philippines, the Straits and India.

Four of these vessels will be required for each of these services and the remaining vessels of the fleet will be operated on the Atlantic. As the building of these ships marks the beginning of a new era in American shipping, by the establishment of regular overseas passenger lines, the details of construction and equipment of the vessels are of more than passing interest.

In the first place the new American liners will embody the latest ideas in the development of hull and machinery construction, combining the characteristics of safety and speed and comfort and convenience, which make the modern liner the mistress of the seas. They are twin screw, turbine-driven vessels of 13,500 gross tons, with a deadweight carrying capacity of 11,000 tons, fitted with oil-burning watertube boilers, and are capable of maintaining a sea speed of 17½ knots with a steaming radius of 11,700 miles. The main particulars of these vessels are as follows:

Length overall	535 feet
Length between perpendiculars	534 feet
Beam, molded	72 feet
Depth to *"A"* deck, molded	50 feet
Draft, summer	30 feet 6 inches
Gross tonnage, about	13,500
Deadweight tonnage, about	11,000
Service speed	17½ knots
Steaming radius	11,700 miles
Shaft horsepower	12,000
Fuel oil capacity	3,267 tons
Boiler feed water	213 tons
Potable water	651 tons
Bale capacity	455,536 cubic feet
Ship's cold storage	9,900 cubic feet
Cargo cold storage	3,950 cubic feet
Number of first class passengers	253
Number of maids	4
Number of second class passengers	300
Number of crew	182

The first-class accommodations will compare favorably with those of the finest ships afloat. The designs of the furniture, draperies, decorations, etc., are being prepared by W. and J. Sloane & Company, New York. As shown by

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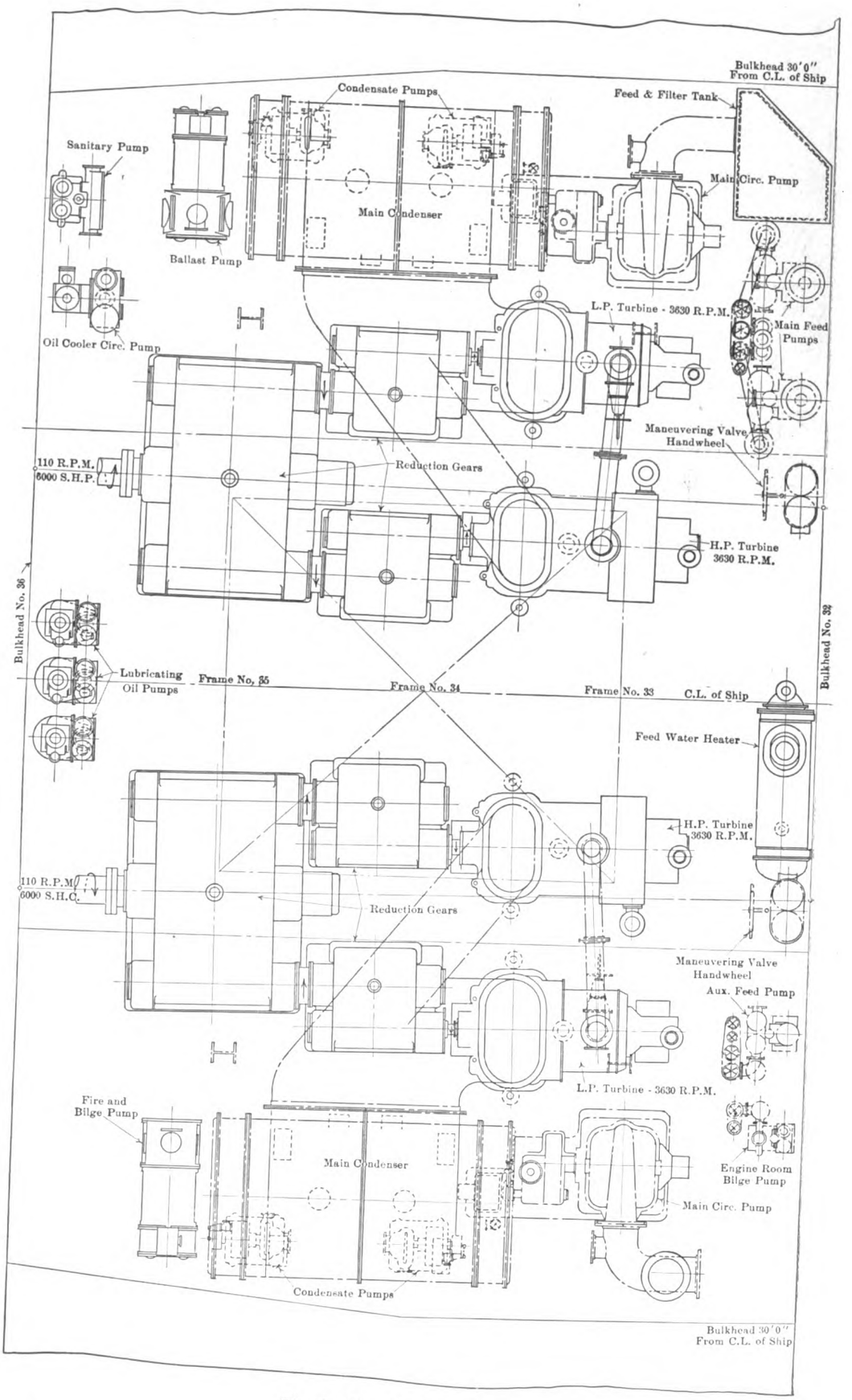

Fig. 5.—Plan of Engine Room

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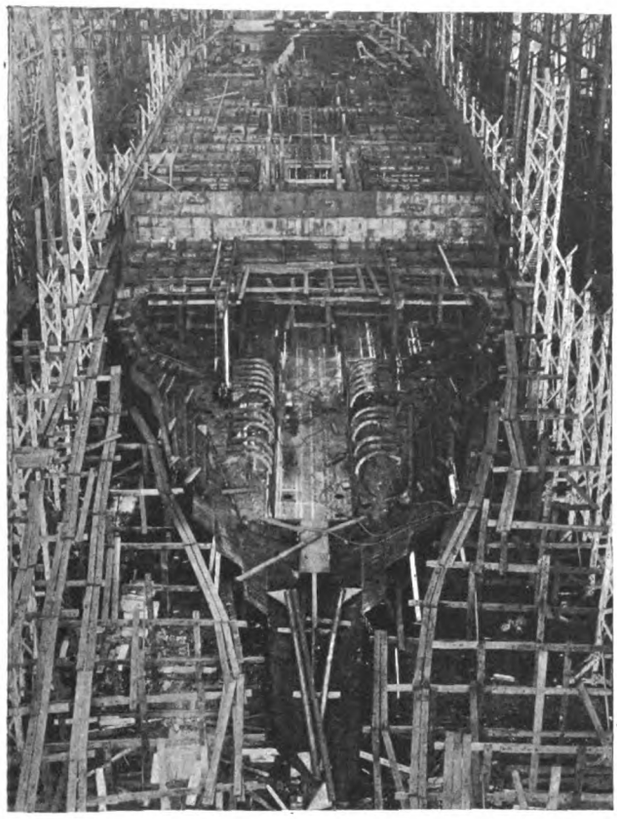

Fig. 6.—Stern View, S. S. *Wenatchee*

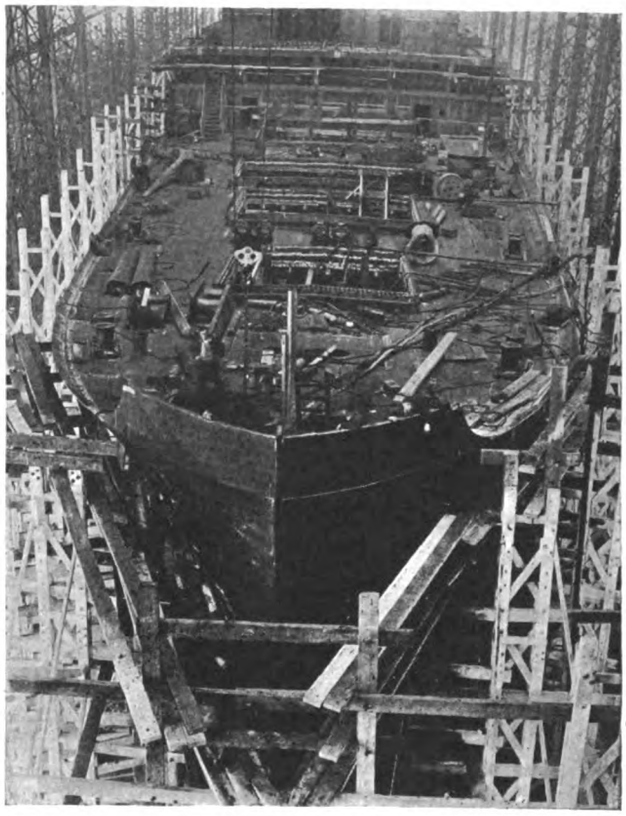

Fig. 7.—Bow View, S. S. *Wenatchee*

the general plans of the vessels, reproduced in this issue, the arrangement of the public rooms, staterooms and private suites provides every convenience and luxury that can be found ashore. In all, there are five decks given over to passenger accommodations, designated as the boat deck, bridge deck, shade deck (*A*), shelter deck (*B*) and upper deck (*C*).

The forward part of the boat deck is given over to the working of the ship and quarters for the navigating officers. Aft on the boat deck is a large first-class lobby, writing room and tea room. At the after end of the tea room is an open veranda.

On either side of the bridge deck is a wide promenade, closed in for the most part by glass windows. Within the deck house are the first class entrance, social hall and smoking room. Forward are two private suites, each consisting of a sitting room, bedroom and bath, and accommodations for four maids.

Below, on the *A* or shade deck, the space amidships is given over to first class staterooms with private baths. Aft of these accommodations on the starboard side is a hospital for passengers and on the port side a hospital for the crew.

The first-class dining room extends clear across the vessel amidships on the *B* or shelter deck. Forward of the dining room are first-class accommodations, and aft on the port side the first-class pantry and galley, while

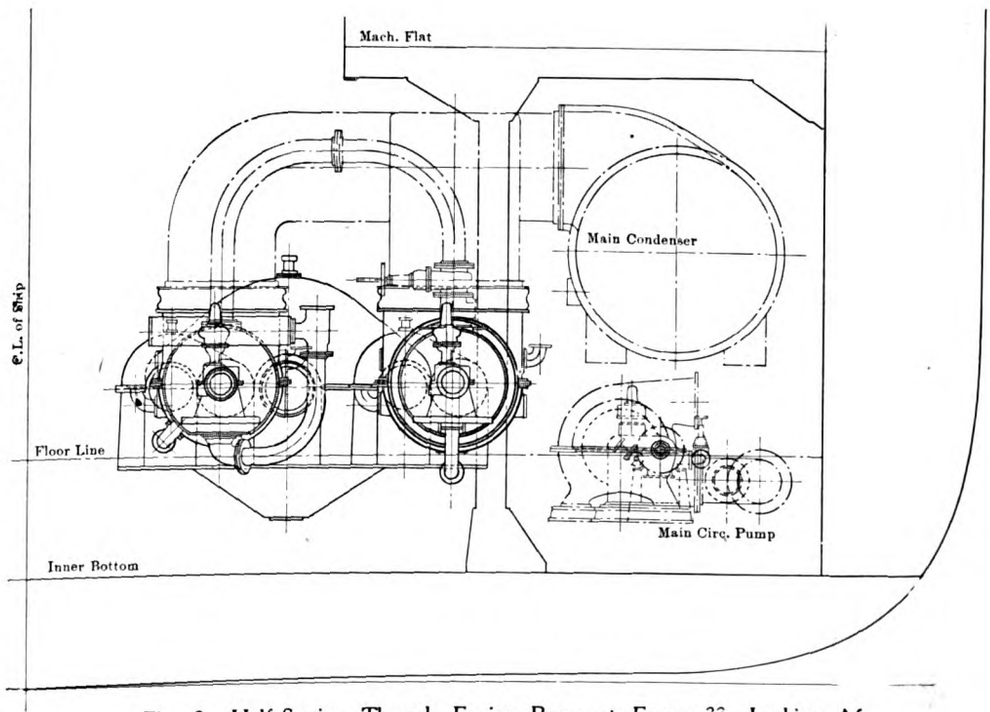

Fig. 8.—Half-Section Through Engine Room at Frame 33, Looking Aft

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on the starboard side abreast the machinery casings are quarters for the engineers and stewards. Aft of the engine room hatch are additional first-class accommodations, while clear aft, on both this and the deck below, are the berthing and mess spaces for the second-class passengers.

Aside from the cargo spaces forward and aft on the *C* or upper deck, the space amidships is taken up by the quarters and mess rooms for the crew, aft of which are the ship's cold storage rooms, laundry, bakery, etc. Clear aft on this deck, as stated above, are part of the accommodations for second-class passengers.

The lifesaving equipment of the vessel includes fourteen 26-foot lifeboats, two 24-foot motor lifeboats and two 18-foot work boats, all stowed on the boat deck under mechanically operated davits.

Hull Construction

The vessels are being classed by both the American Bureau of Shipping and Lloyds. The hull is built on the Isherwood system of longitudinal framing with a double bottom extending throughout the length of the vessel. Thirteen transverse bulkheads, all of which, with the exception of one in way of the first-class dining room, extend up to the shade deck, divide the hull into fourteen watertight compartments.

For three-fifths length amidships, there is an outer keel 52 inches by .92 inch, and an inner keel 38½ inches by .74 inch, while at the ends the keel is reduced to a single plate .84 inch thick. The center girder is 50 inches deep and .64 inch thick amidships reduced to .50 inch at the ends and increased to .68 inch in the boiler space. The center girder is joined to the keel by double continuous angles 6 inches by 6 inches by .56 inch reduced to .50 inch at the ends, and to the tank top by double continuous angles 3½ inches by 3½ inches by .58 inch reduced to .54 inch at the ends, and increased to .68 inch in the boiler space. On each side of the center girder there are three side girders of .46 inch plate amidships reduced to .40 inch at the ends and increased to .46 inch in the boiler space.

The bottom plating is .74 inch to .52 inch, and the side plating .70 inch for one-half length reduced to .48 inch at the ends. The sheer strake at the shade, or *A*, deck is .88 inch for one-half length reduced to .48 inch at the ends. The tank top plating is .48 inch to .42 inch thick, increased to .58 inch in the engine room and to .62 inch in the boiler space. The margin plate, which extends straight out to the side of the vessel, is .56 inch, increased to .60 inch in the boiler space. The deck plating and stringers are as follows:

Deck	Plating	Stringer
(*A*) Shade	.50 inch to .38 inch	.74 inch to .46 inch
(*B*) Shelter	.44 inch to .32 inch	.48 inch to .46 inch
(*C*) Upper	.36 inch to .32 inch	.42 inch
(*D*) Main	.34 inch to .30 inch	.40 inch

Longitudinals and Transverses

The longitudinals are all of channel sections of the following sizes:

Nos. 1 and 2: 6 inches by .35 inches by 3.5 inches by 15 pounds.

Nos. 3 and 4: 7 inches by .313 inch by 3.313 inches by 15.6 pounds.

Nos. 5 and 6: 7 inches by .438 inch by 3.438 inches by 18.6 pounds.

Nos. 7, 8 and 9: 10 inches by .375 inch by 3.375 inches by 21.8 pounds.

Nos. 10 and 11: 10 inches by .475 inch by 3.47 inches by 26.4 pounds.

No. 12: 10 inches by .50 inch by 3.5 inches by 27.2 pounds.

No. 13: 10 inches by .55 inch by 3.55 inches by 28.9 pounds.

Bottom: 7 inches by 3.438 inches by 3.438 inches by 18.6 pounds.

Shade, shelter and upper decks: 6 inches by 3.5 inches by 3.5 inches by 15 pounds.

Main deck: 7 inches by 3.313 inches by 3.313 inches by 15.6 pounds.

Tank top: 7 inches by .35 inch by 3.35 inches by 16.5 pounds.

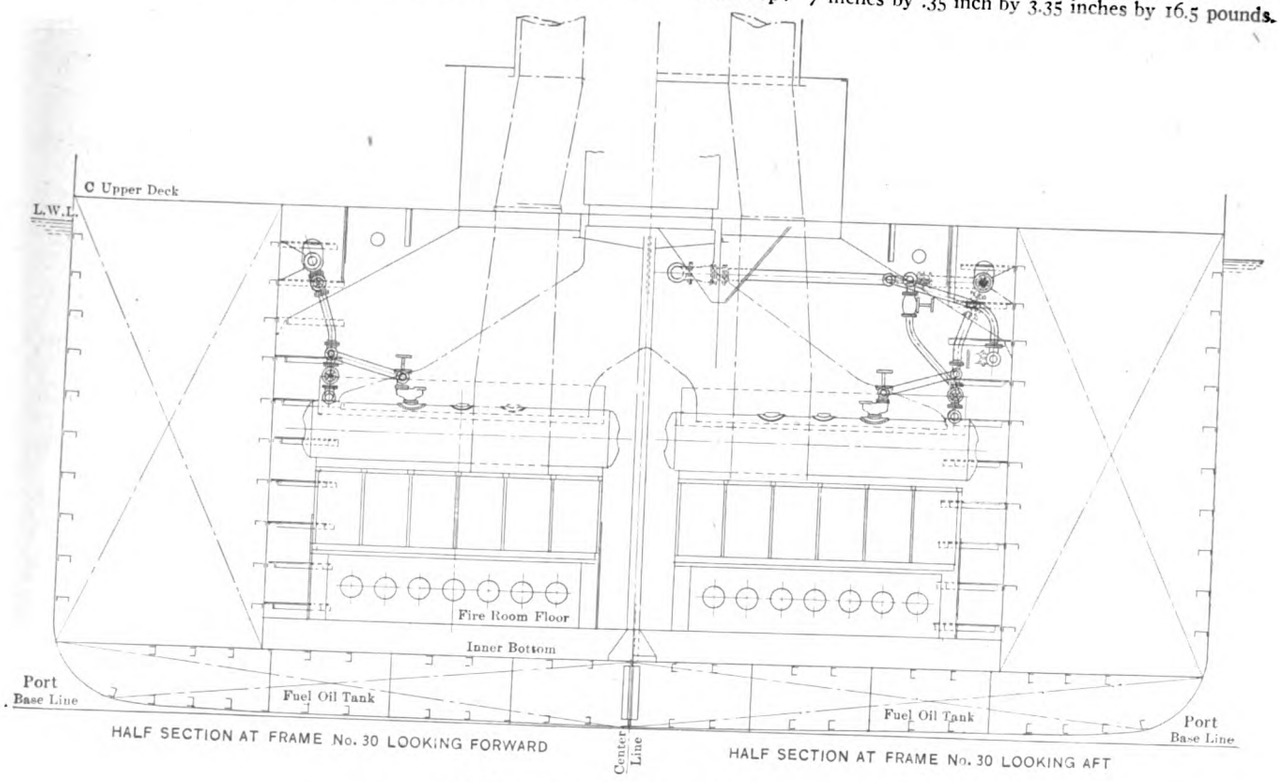

Fig. 9.—Section Through Boiler Room

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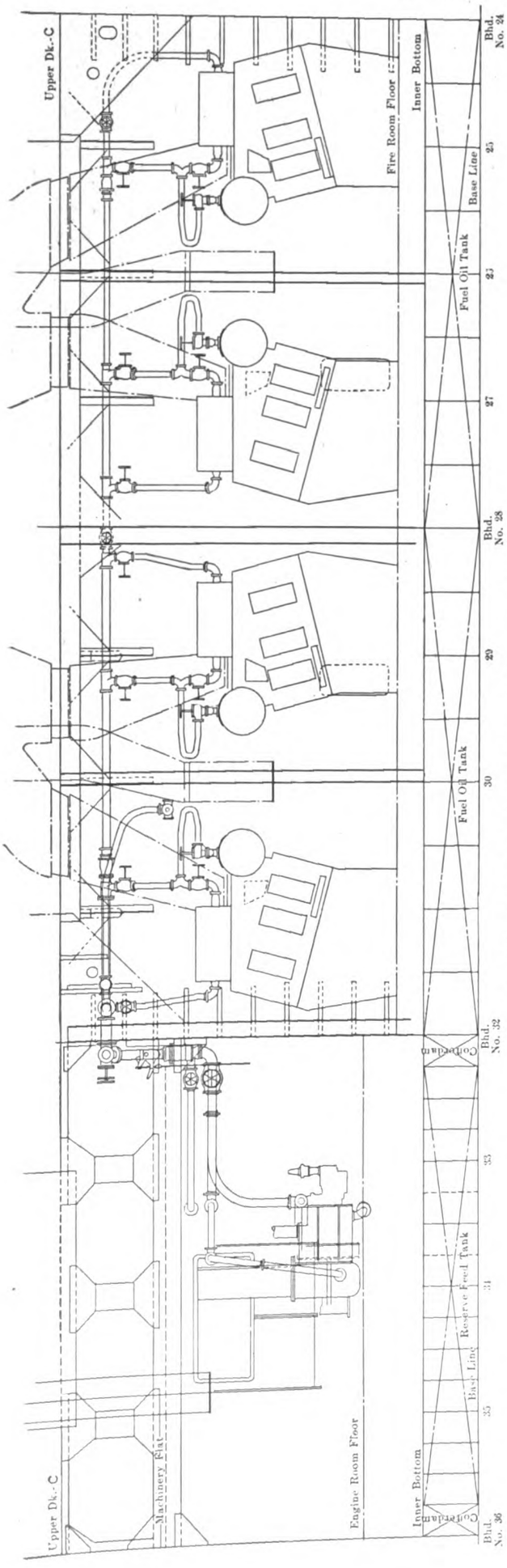

Fig. 10.—Longitudinal Section Through Machinery Space

The transverses, spaced 9 feet 6 inches apart and fitted with an angle face bar 6 inches by 4 inches by .70 inch throughout, are made up as follows:

	Side	*Deck*
Shade deck.....	18 inches by .44 inch	13 inches by .44 inch
Shelter deck.....	20 inches by .44 inch	13 inches by .44 inch
Upper deck.....	22 inches by .44 inch	13 inches by .44 inch
Main deck.....	31 inches by .50 inch	14 inches by .44 inch

The floors are .48 inch amidships, reduced to .42 inch at the ends and increased to .54 inch in the boiler space. The angles connecting the floors to the bottom and tank top plating are 3½ inches by 3½ inches by .52 inch to .48 inch.

For handling cargo there are five hatches 19 feet wide by 30 feet long; two 19 feet wide by 24 feet long and two 19 feet wide by 18 feet long. The hatches are served by thirty-two cargo booms of 6 tons capacity each, and one 30 ton boom. Hatches Nos. 2 to 8 inclusive are served by four booms each, while hatches Nos. 1 and 9 have but two booms each. Thirty-two 9¼-inch by 12-inch winches are provided, each capable of handling a load of 5 tons on a single whip.

Propelling Machinery

Propulsion is by twin screws, each 17 feet diameter, driven by two sets of double reduction geared turbines at a normal speed of 110 revolutions per minute. The turbines are of the Westinghouse double-flow type, designed to develop a total of 12,000 shaft horsepower. Each shaft has one high-pressure and one low-pressure turbine driving the propeller through a system of DeLaval double-reduction gears. Each turbine is installed forward of its own independent reduction gear, and each of these reduction gears is connected to its respective outboard or inboard pinion of a second reduction gear, which is installed at the forward end of the propeller shaft. With a steam pressure at the turbine chest of 250 pounds per square inch, and a vacuum of 28 inches at the turbine exhaust the turbines are designed to run at a speed of 3,630 revolutions per minute, driving the propeller at a speed of 110 revolutions per minute.

Steam is supplied at a working pressure of 265 pounds per square inch and 75 degrees superheat by eight oil-fired Babcock and Wilcox watertube boilers operated under the closed stokehold system of forced draft. With a bunker capacity of 3,267 tons of fuel oil the vessels will have a steaming radius at 17½ knots speed of 11,700 miles.

Engines for French Government

FOR several months past the National Marine Engine Works, Inc., Scranton, Pa., has been working on engine contracts for the French Government. In general, the triple-expansion inverted condensing engine of the type supplied to the Emergency Fleet Corporation has been required by the contracts.

This particular engine of 700 horsepower is built with cylinders 15½ inches, 26 inches and 44 inches diameter by 26 inches stroke. When completed in the shop, the engines are ready for installation in ships of the Leparmentier type built for the French Government by the Foundation Company at their New Orleans yard, for the thrust blocks, stern tube bearings, shafts and propellers, with the necessary fittings and spares, have been previously set up for test.

The engines are designed for 185 pounds per square inch working pressure, a vacuum of 26 inches, and to run at 115 revolutions per minute.

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502-Foot Passenger and Cargo Vessels

Shipping Board Cargo Steamers with Limited Passenger Accommodations to Carry 12,000 Tons Deadweight at 14 Knots Speed

As a part of the Shipping Board program for overseas passenger and cargo service, the New York Shipbuilding Corporation, Camden, N. J., is building a number of twin screw 14-knot steamships of 12,000 tons deadweight capacity, which will have elaborate accommodations for 78 first-class passengers. The principal dimensions of these vessels are as follows:

Length overall	522 feet 5 inches
Length between perpendiculars	502 feet
Beam, molded	62 feet
Depth to "A" deck	42 feet
Draft, summer	31 feet 9 inches
Gross tonnage, about	10,500
Deadweight tonnage, about	12,000
Service speed	14 knots
Indicated horsepower	6,000
Fuel oil capacity	3,476 tons
Boiler feed water	215 tons
Domestic water	241 tons
Bale capacity	465,940 cubic feet
Ship's cold storage	5,300 cubic feet
Cargo cold storage	52,300 cubic feet
Number of first class passengers	78
Number of crew	115

These vessels are being classed by the American Bureau of Shipping. The accommodations, while limited to 78 first-class passengers, are very elaborate and lose nothing in comparison with the finest ships afloat. The passengers' staterooms and public rooms are situated on the "A," bridge and promenade decks. The general finish of the staterooms is white with mahogany trim. The beds are of square metal tubing, enameled to harmonize with the finish of the rooms. The public rooms are spacious and tastefully furnished and decorated. The dining saloon is finished in Colonial period; the smoking room in fumed oak, mission style; the social hall furniture and finish are of the Adams design. The general arrangement of the accommodations is shown on the plans reproduced herewith.

The equipment for handling cargo is unusually complete. In all there are nine large cargo hatches; five are 17 feet 6 inches by 25 feet, two are 19 feet by 20 feet, one is 18 feet by 15 feet, and one is 17 feet 6 inches by 15 feet. In addition there are two smaller hatches 8 feet by 15 feet, used for the refrigerated space. The cargo is

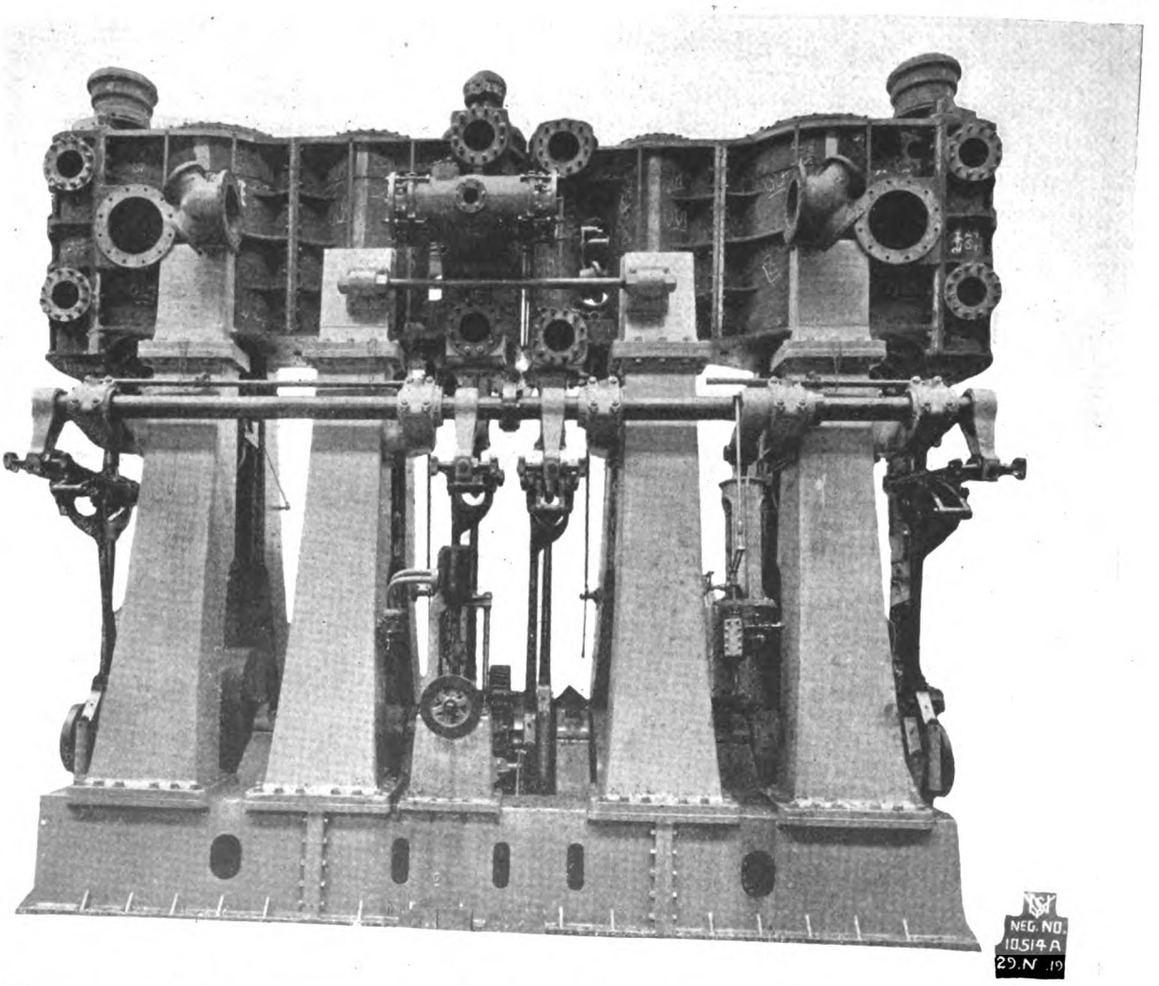

Fig. 1.—One of the Four-Cylinder, Triple-Expansion Main Propelling Engines of 3,000 Indicated Horsepower Built by the New York Shipbuilding Corporation for Installation on the 502-Foot Passenger and Cargo Vessels

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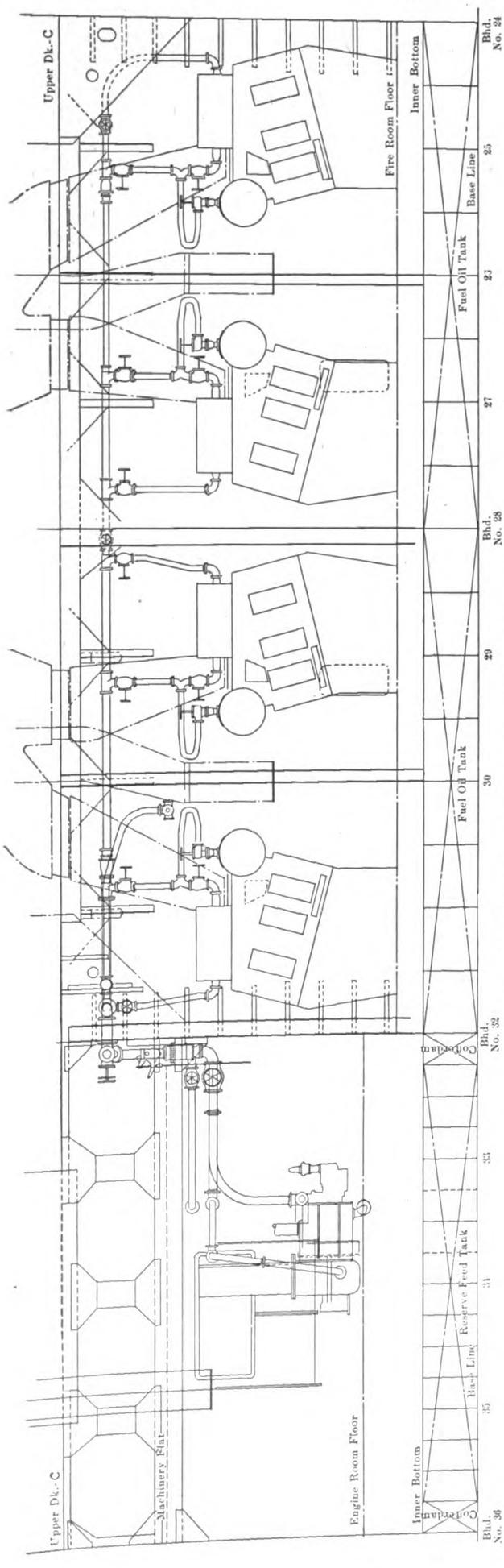

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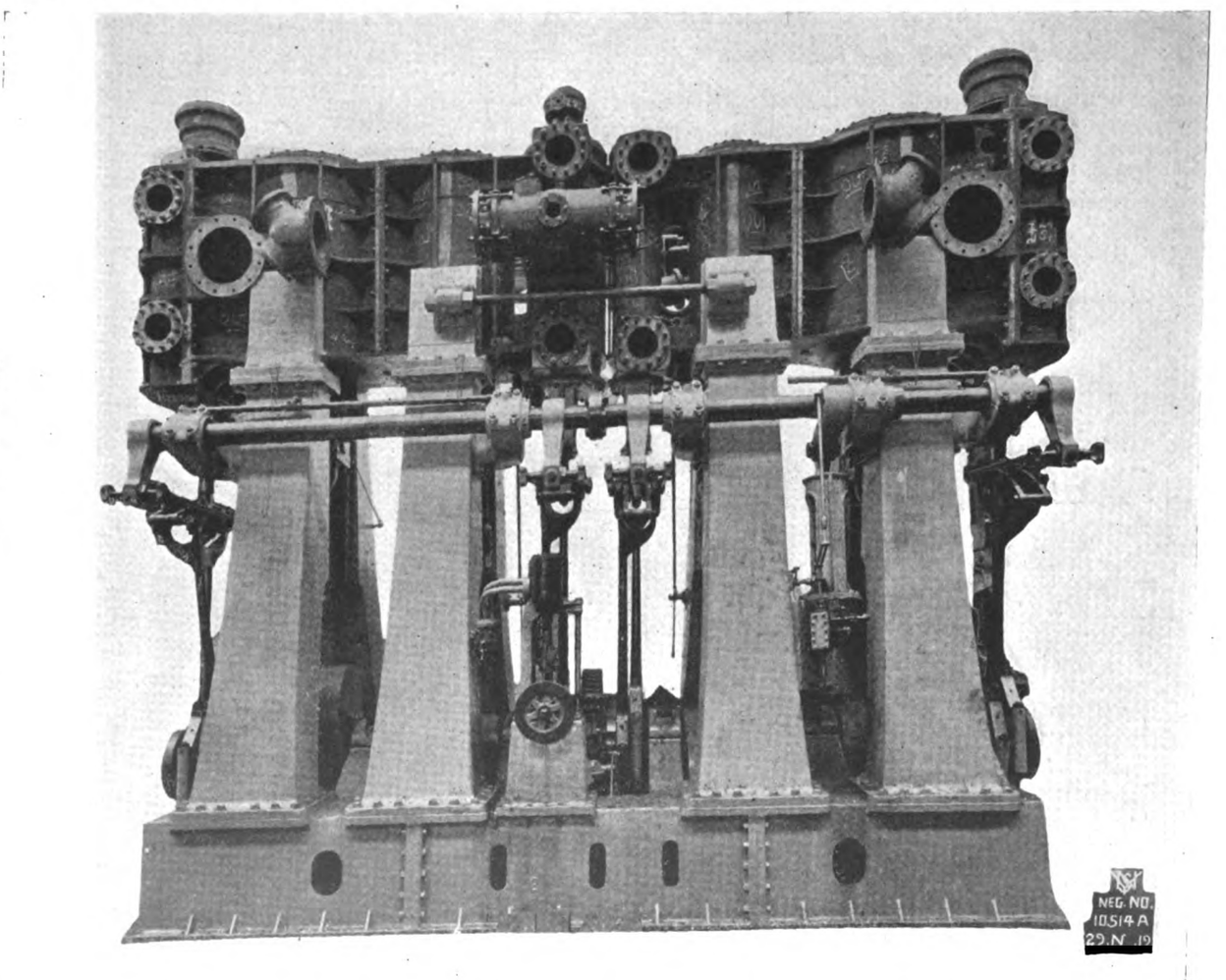

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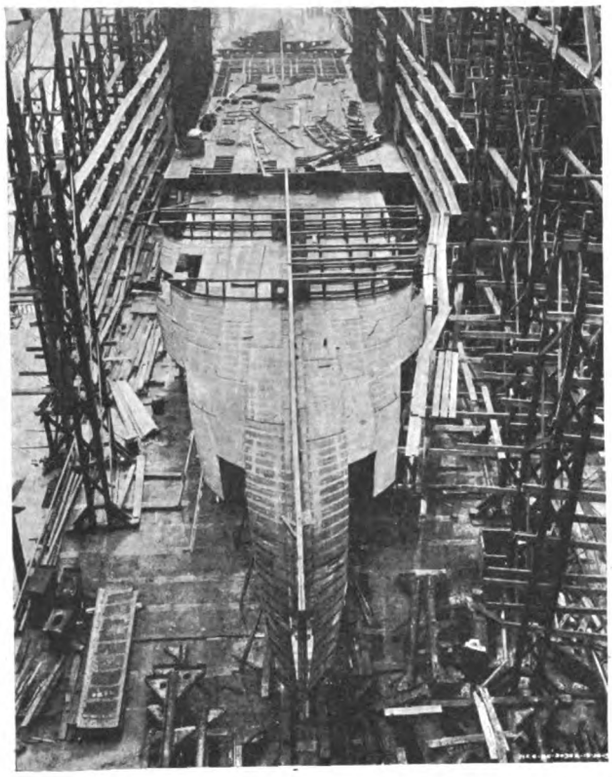

Fig. 2.—Bow View, Showing Double Bottom

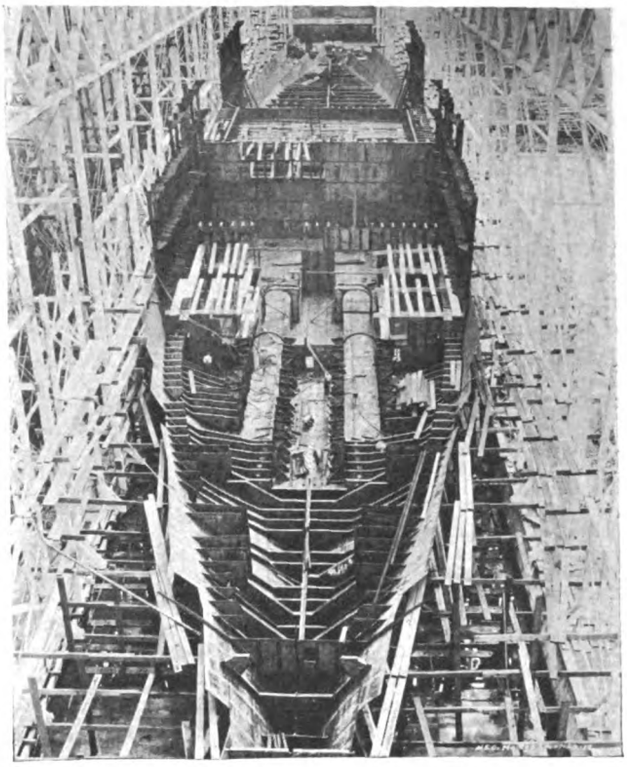

Fig. 3.—Stern View, Showing Framing

handled by thirty-two 6-ton booms, stopped to ten king-posts, and a 30-ton boom. The cargo handling equipment includes twenty steam winches, sixteen of which are of the 8¼-inch by 8-inch double cylinder, single drum, single geared, reversible type with one winch head and two other winches forward and two aft of the same size, but with two large winch heads each.

These vessels are built on the transverse system of framing with a double bottom throughout, and with the hull further subdivided into 14 watertight compartments by 13 transverse bulkheads, all of which extend up to the *A* deck.* Amidships the hull has no sheer. *B* and *C*

* For midship section and details of hull construction see MARINE ENGINEERING, April, 1919.

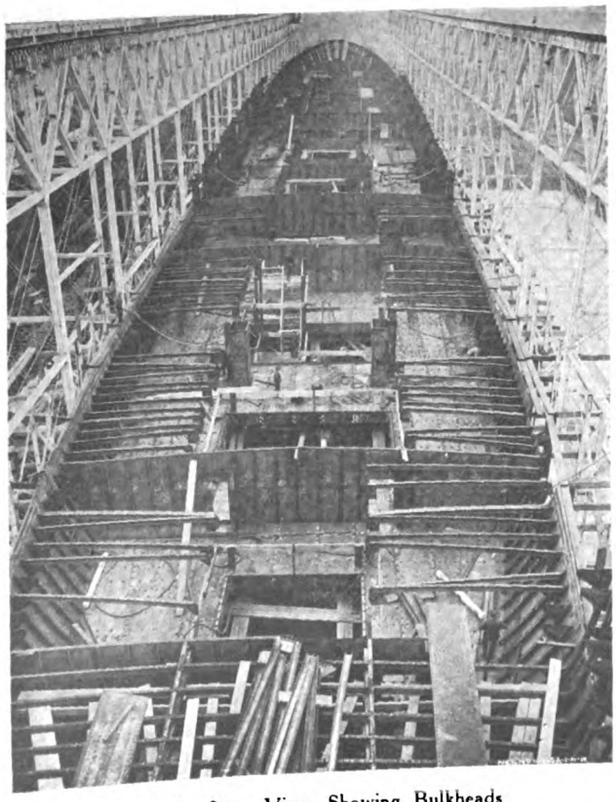

Fig. 4.—Stern View, Showing Bulkheads

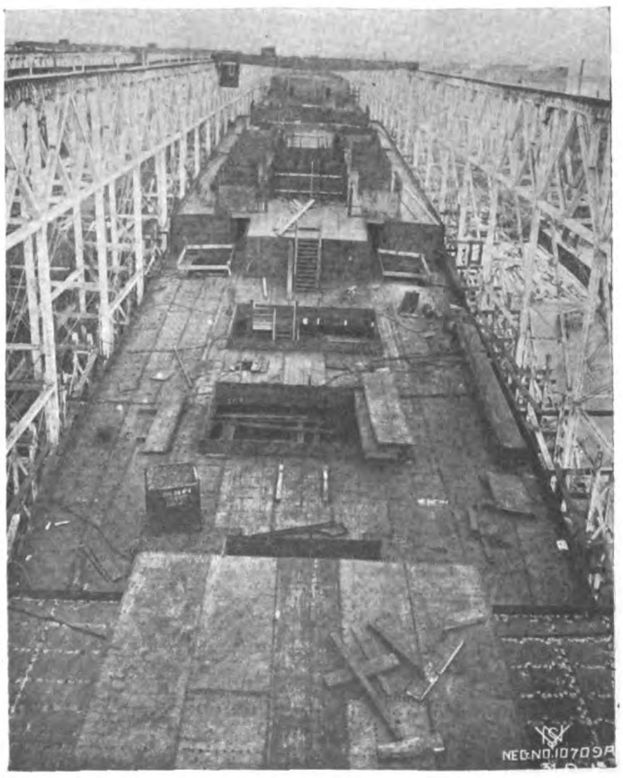

Fig. 5.—Stern View, Showing Weather Decks

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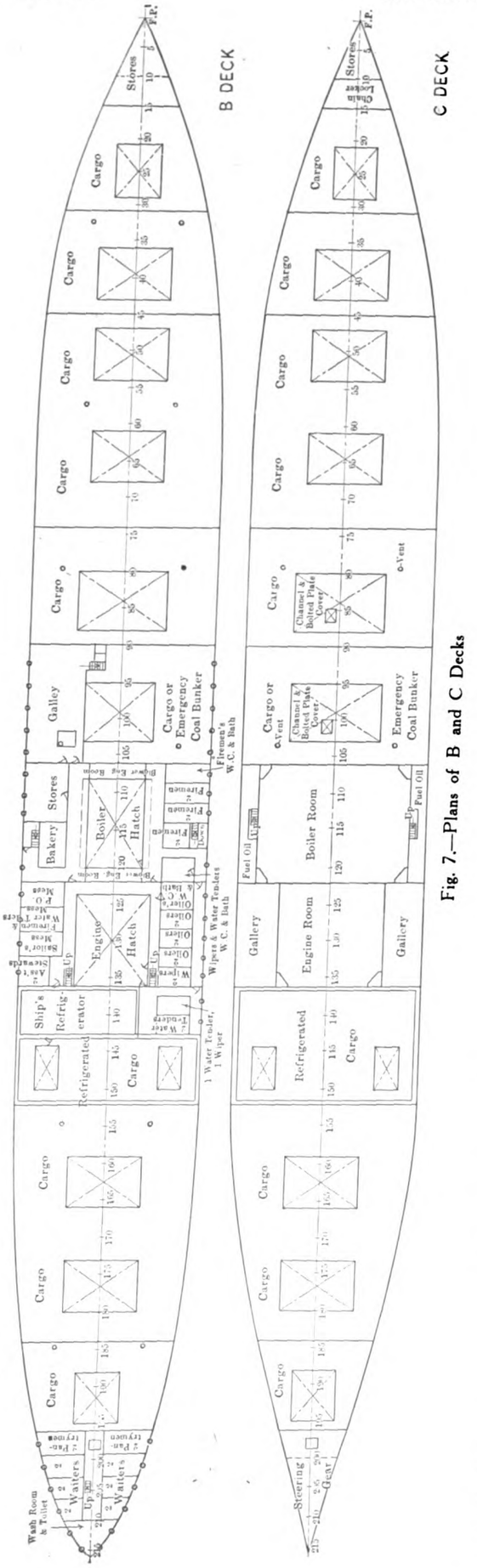

Fig. 7.—Plans of B and C Decks

decks have no camber, but all weather decks have a camber of 15 inches in 62 feet. The frames above the tank top are channels, except at the ends, where they are of angles with reverse frames. Solid floors are fitted in the double bottom on every third frame and beyond the double bottom on every frame. Double frames are fitted in the double bottom from three-fifths length forward to the collision bulkhead. Alternate frames of angles, bracketed to the bridge deck beams, are fitted in the bridge. All of the frames and reverse frames in the peaks run clear up to the poop and forecastle decks. The frames are cut and bracketed in way of all watertight flats and over fuel oil bunkers.

No web frames are fitted in the cargo holds, but two are fitted in the engine room, and others in the fuel oil bunkers in the boiler space as needed. The decks are all plated with steel with channel beams on every frame. The cargo holds are free of pillars, as the decks are supported by heavy girders.

Cold Storage Compartments

Ample cold storage space is provided as shown on the plans, there being separate compartments for meats and vegetables, etc. The former are to be maintained at 20 degrees F., and the latter at 40 degrees F. under tropical conditions. The walls and ceilings of the cold storage spaces consist of two thicknesses of 7/8-inch tongued and grooved yellow pine, two thicknesses of 2-inch cork, one thickness of 7/8-inch tongued and grooved yellow pine and finished on the inside with one thickness of 7/8-inch tongued and grooved spruce, each thickness of wood and cork being separated by two thicknesses of waterproof insulating paper.

In addition to the cargo winches already mentioned the deck machinery includes a steam windlass on the forecastle deck and steam, and hand-steering gear with telemotor control from the bridge.

Propelling Machinery

Propulsion is by twin screws of the built-up type, about 16 feet 6 inches diameter driven by two sets of four-cylinder, triple expansion, vertical, inverted reciprocating engines with cylinders 24 inches, 40½ inches, 54 inches and 54 inches diameter by 45 inches stroke, each of which is designed to develop at 105 revolutions per minute 3,000 indicated horsepower. Steam is supplied at 220 pounds per square inch by six oil-fired single-end Scotch boilers with a total heating surface of about 16,000 square feet working under a system of heated forced draft. The boilers are 15 feet 3 inches diameter by 11 feet 6 inches long between heads, each fitted with three 45-inch Morison corrugated furnaces leading to separate combustion chambers. The draft fans are driven by slow speed vertical single-cylinder reciprocating engines, of sufficient capacity to maintain a static pressure of 3 inches of water. The fuel oil is carried in bunkers fitted at the sides of the boiler space reaching from the tank top to *B* deck.

There are two independent main condensers, each with 4,500 square feet of cooling surface. Each condenser has a centrifugal circulating pump with 16-inch suction and discharge with a capacity of 5,000 gallons per minute against a head of 25 feet, driven by a single cylinder 10-inch by 10-inch vertical engine. The air pumps are of the vertical twin-beam type with one steam and two air cylinders 14 inches and 28 inches by 18 inches. There is also an auxiliary condenser with 1,000 square feet of cooling surface mounted on combined air and circulating pumps.

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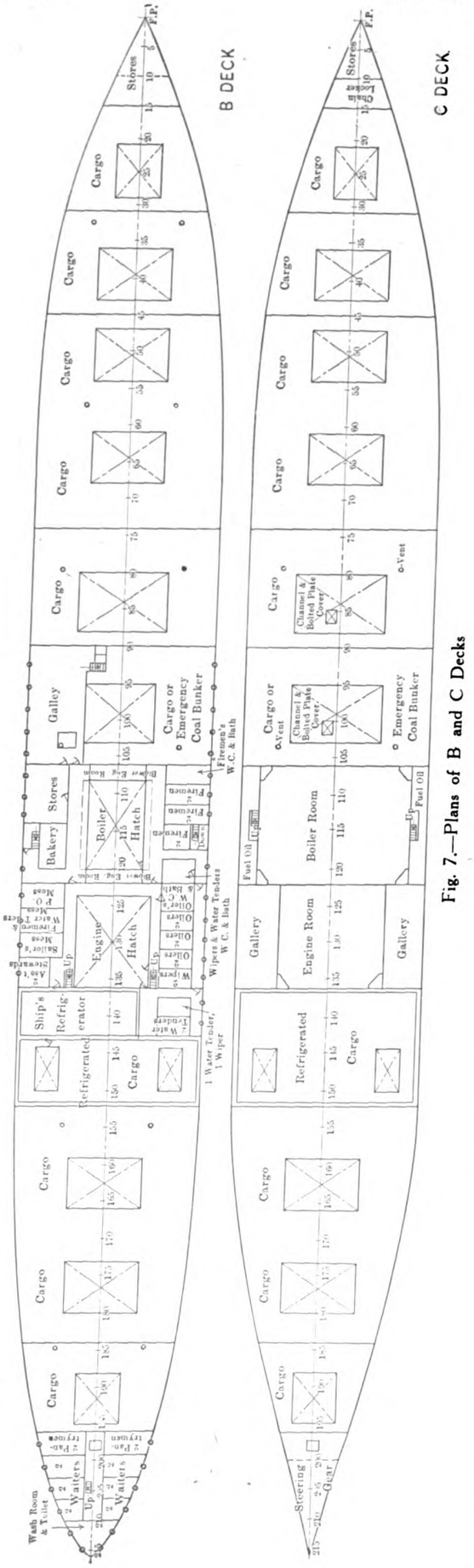

Fig. 7.—Plans of B and C Decks

decks have no camber, but all weather decks have a camber of 15 inches in 62 feet. The frames above the tank top are channels, except at the ends, where they are of angles with reverse frames. Solid floors are fitted in the double bottom on every third frame and beyond the double bottom on every frame. Double frames are fitted in the double bottom from three-fifths length forward to the collision bulkhead. Alternate frames of angles, bracketed to the bridge deck beams, are fitted in the bridge. All of the frames and reverse frames in the peaks run clear up to the poop and forecastle decks. The frames are cut and bracketed in way of all watertight flats and over fuel oil bunkers.

No web frames are fitted in the cargo holds, but two are fitted in the engine room, and others in the fuel oil bunkers in the boiler space as needed. The decks are all plated with steel with channel beams on every frame. The cargo holds are free of pillars, as the decks are supported by heavy girders.

Cold Storage Compartments

Ample cold storage space is provided as shown on the plans, there being separate compartments for meats and vegetables, etc. The former are to be maintained at 20 degrees F., and the latter at 40 degrees F. under tropical conditions. The walls and ceilings of the cold storage spaces consist of two thicknesses of 7/8-inch tongued and grooved yellow pine, two thicknesses of 2-inch cork, one thickness of 7/8-inch tongued and grooved yellow pine and finished on the inside with one thickness of 7/8-inch tongued and grooved spruce, each thickness of wood and cork being separated by two thicknesses of waterproof insulating paper.

In addition to the cargo winches already mentioned the deck machinery includes a steam windlass on the forecastle deck and steam, and hand-steering gear with telemotor control from the bridge.

Propelling Machinery

Propulsion is by twin screws of the built-up type, about 16 feet 6 inches diameter driven by two sets of four-cylinder, triple expansion, vertical, inverted reciprocating engines with cylinders 24 inches, 40½ inches, 54 inches and 54 inches diameter by 45 inches stroke, each of which is designed to develop at 105 revolutions per minute 3,000 indicated horsepower. Steam is supplied at 220 pounds per square inch by six oil-fired single-end Scotch boilers with a total heating surface of about 16,000 square feet working under a system of heated forced draft. The boilers are 15 feet 3 inches diameter by 11 feet 6 inches long between heads, each fitted with three 45-inch Morison corrugated furnaces leading to separate combustion chambers. The draft fans are driven by slow speed vertical single-cylinder reciprocating engines, of sufficient capacity to maintain a static pressure of 3 inches of water. The fuel oil is carried in bunkers fitted at the sides of the boiler space reaching from the tank top to *B* deck.

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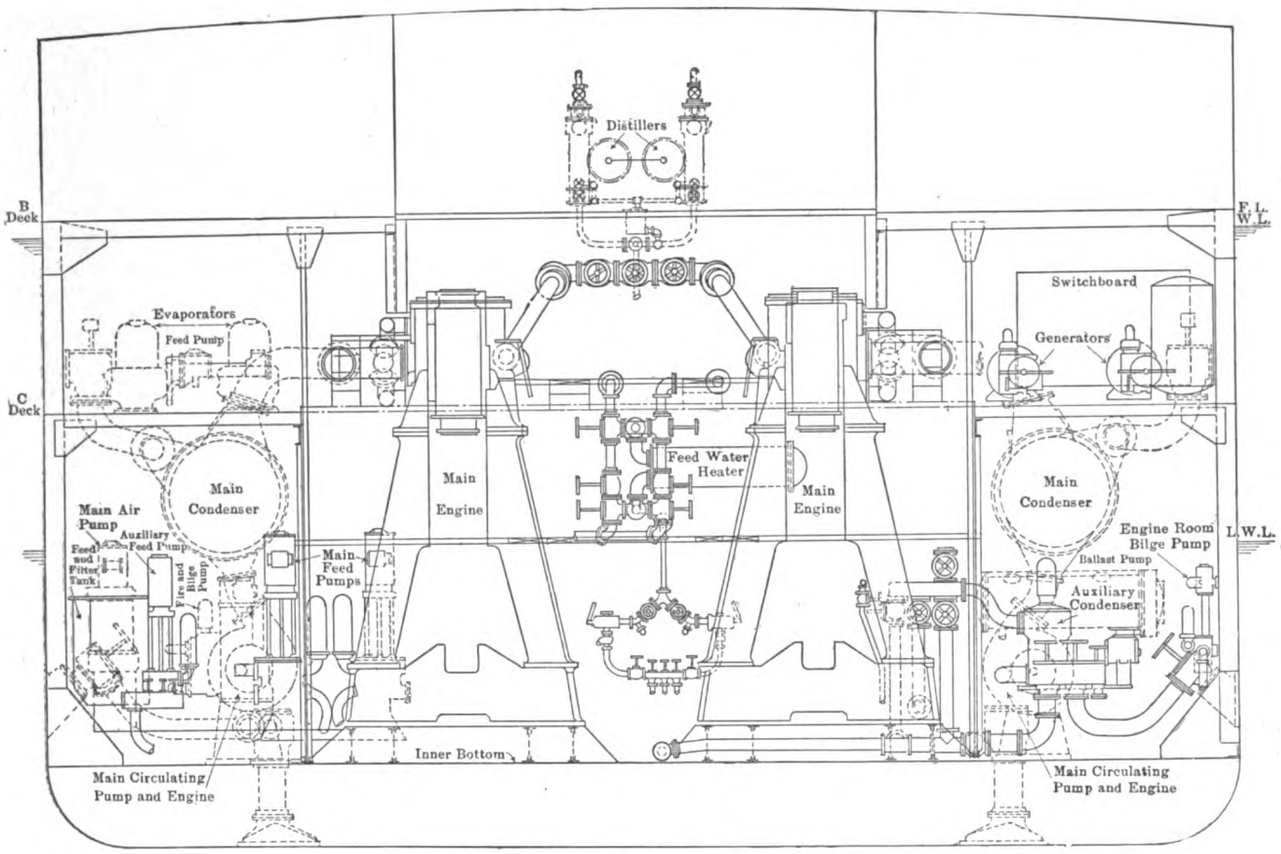

Fig. 8.—Section Through Engine Room

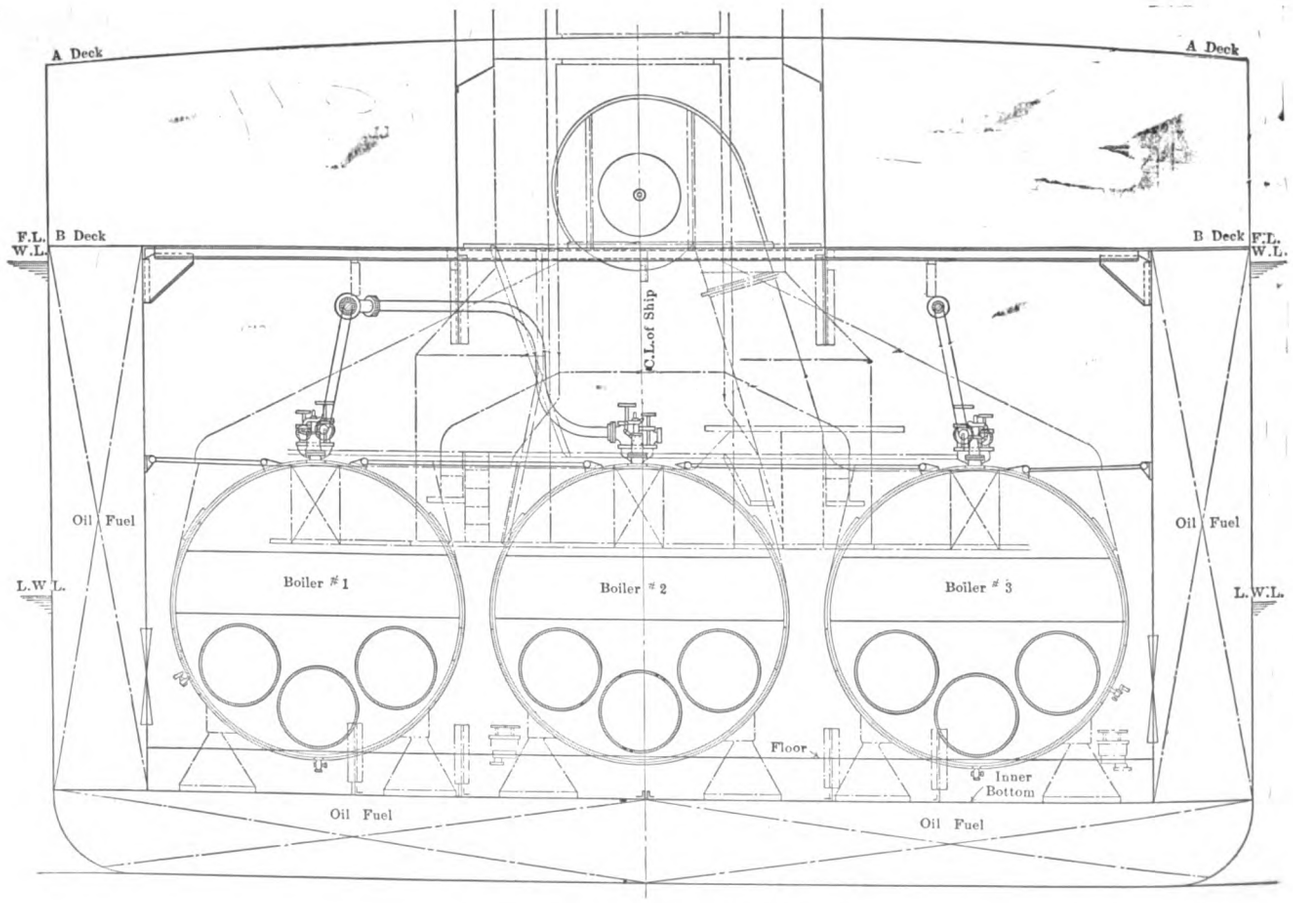

Fig. 9.—Section Through Boiler Room

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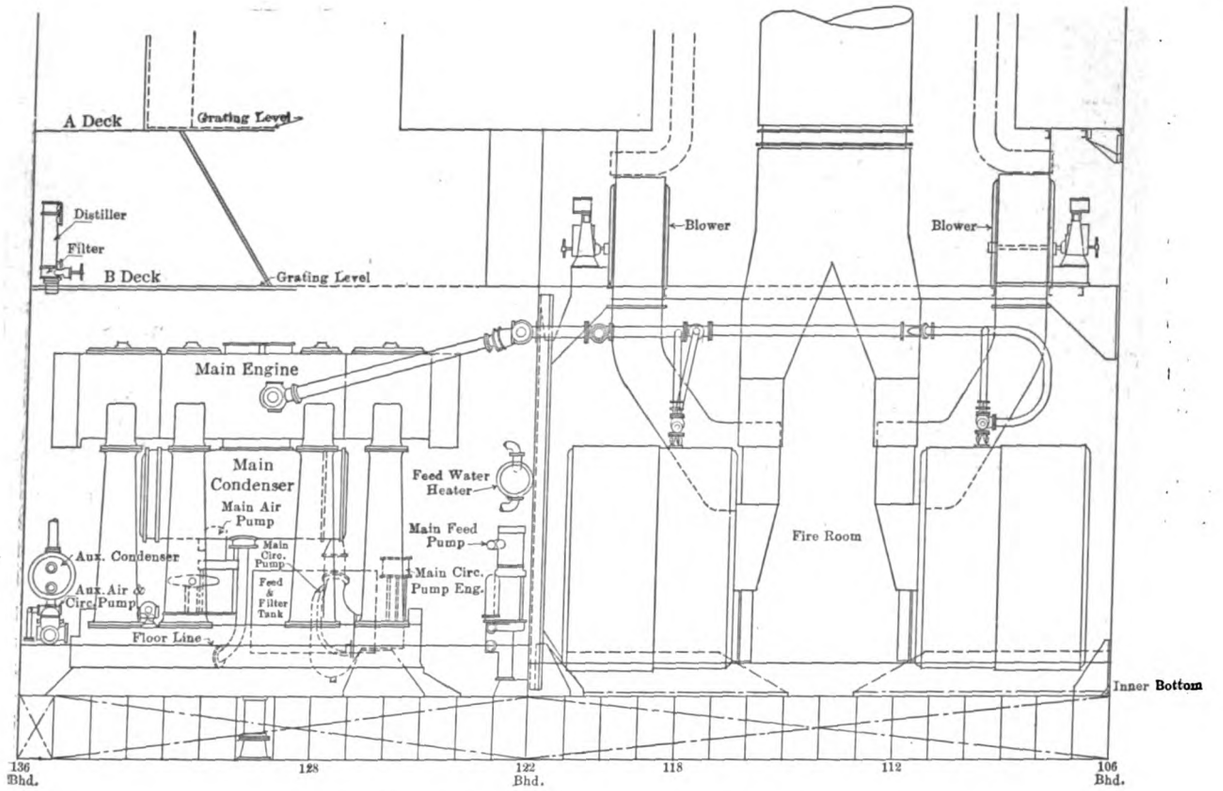

Fig. 10.—Longitudinal Section Through Machinery Space

PUMPS

The following independent pumps are fitted:

Two main feed, 14 inches by 10 inches by 24 inches, vertical simplex.

One auxiliary feed, 10 inches by 7 inches by 24 inches, vertical simplex.

One ballast, 10 inches by 12 inches by 12 inches, horizontal duplex.

One fire and bilge and general service, 12 inches by 8 inches by 12 inches, horizontal duplex.

One sanitary, 7½ inches by 9 inches by 10 inches, horizontal duplex.

One engine room bilge pump, 6 inches by 7 inches by 12 inches, vertical simplex.

Two fresh water, 7½ inches by 6 inches by 10 inches, horizontal duplex.

One drinking water 4½ inches by 3¾ inches by 4 inches, horizontal duplex.

One evaporator feed, 7½ inches by 6 inches by 10 inches, horizontal duplex.

One auxiliary and circulating, 10 inches by 12 inches by 14 inches by 12 inches, horizontal simplex.

One oil transfer, 7½ inches by 9 inches by 10 inches, vertical duplex.

Two oil service, 7½ inches by 4½ inches by 10 inches, vertical duplex.

One ice machine condenser circulating, 6 inches by 5¾ inches by 6 inches, horizontal duplex.

One brine circulating, 6 inches by 5¾ inches by 6 inches, horizontal duplex.

The auxiliary machinery also includes a feed water heater with a capacity for heating 125,000 pounds of feed water per hour from 90 to 212 degrees F. when using exhaust steam at a pressure of 5 pounds per square inch gage; two 25-ton evaporators; two distillers, each with a capacity for distilling 3,000 gallons of water per 24 hours, and a feed and filter tank of 1,400 gallons capacity in the engine room.

100-Foot Wooden Harbor Tugs

A LARGE number of 100-foot wooden harbor tugs were built during the war, and since the war several additional vessels of this type are being constructed by such representative shipyards as those of the Consolidated Shipbuilding Corporation, Morris Heights, New York, Northwest Engineering Works, Green Bay, Wis., the Leathem and Smith Towing and Wrecking Company, Sturgeon Bay, Wis., the Gibbs Gas Engine Company, the John H. Mathis Company, Camden, N. J., etc. The plans published herewith show the design for this

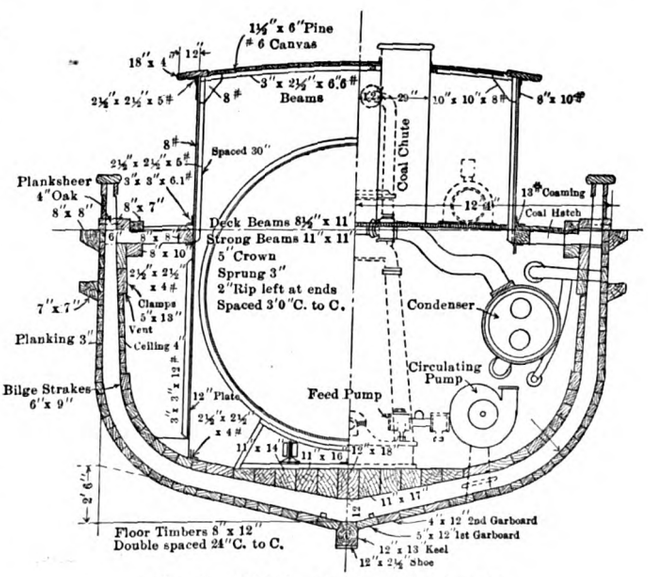

Fig. 1.—Midship Section, 100-Foot Tug

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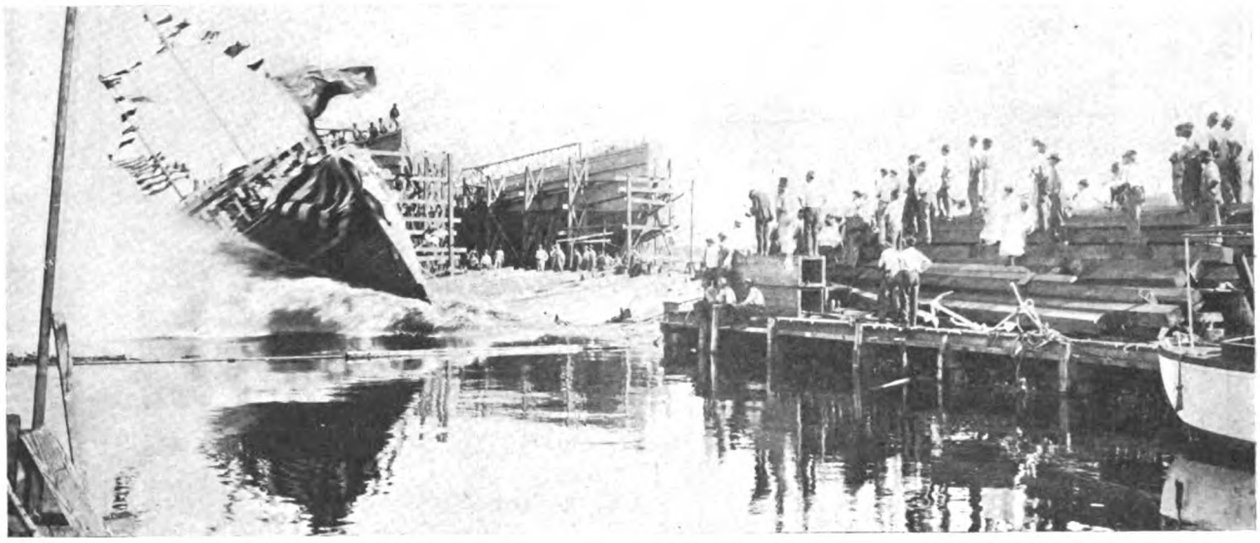

Fig. 2.—Launching of Tug *Condor*

type of vessel developed by J. Murray Watts, naval architect, Philadelphia, Pa., for the United States Shipping Board. Forty-two of these tugs have so far been built according to these designs, and the photographs show (in Fig. 5) the tug *Energy,* as completed by the Northwest Engineering Works, (in Fig. 2) the launch of the *Condor,* by the Gibbs Gas Engine Company; and (in Fig. 4) the *Hawk,* under construction by the Gibbs Gas Engine Company.

These boats are strongly built of wood with oak frames

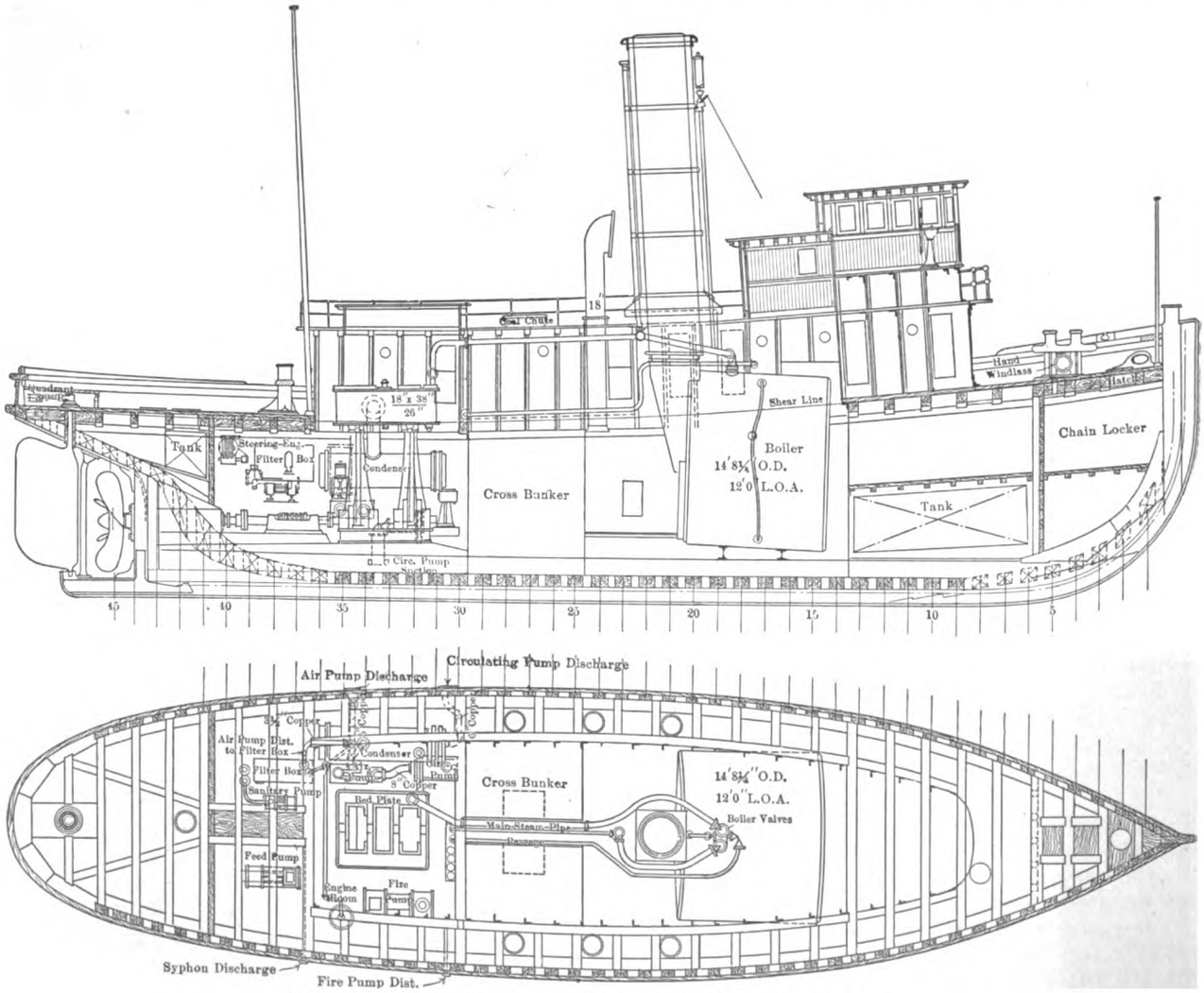

Fig. 3.—General Arrangement Plans of 100-Foot Wooden Tug

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Fig. 4.—Wooden Tug *Hawk* Under Construction

and hard pine planking. The main bulkheads are of steel and the pilot house of wood. The principal dimensions of the tugs are as follows:

Length overall	100 feet 8 inches
Length between perpendiculars	94 feet 10 inches
Beam, molded	24 feet
Depth, molded	14 feet 7 inches
Draft, aft	13 feet 2 inches
Draft, forward	12 feet 3 inches

The keel is of oak, 12 inches by 15 inches; the planking, of hard pine, varies from 5 inches to 3 inches in thickness; the frames are of oak, 8 inches by 12 inches, spaced 24 inches between centers. The keelsons are built up of 11-inch and 12-inch hard pine. Special care has been taken in the specifications to insure the best of fastenings throughout, with the result that the boats have shown up well under rigid tests.

The general arrangement, as shown in the plans, provides quarters for the crew forward with berths and lockers for eight men. A ladder leads from these quarters to a companionway in the forward end of the deckhouse. The boiler and the coal bunkers are amidships, and the engine room aft. In the main deckhouse there is a galley and mess room forward, a pilot room and a lamp room amidships, and two double staterooms forward of the engine room. On top of the deckhouse is the pilot house, and behind the pilot house the captain's cabin.

Propulsion is by a four-bladed propeller 9 feet in diameter and 12 feet pitch, driven by a vertical compound engine with cylinders 18 inches and 38 inches in diameter by 26 inches stroke supplied with steam at a pressure of 155 pounds per square inch, by one Scotch boiler, 14 feet 6 inches diameter and 12 feet long, having a heating surface of 2,506 square feet and a grate area of 747 square feet.

The following figures represent the average performance of one of these tugs during the trial trip:

Revolutions per minute of main engine	88
Steam pressure at boiler, pounds per square inch	148
Steam pressure at engine, pounds per square inch	146
Vacuum, inches	25.5
Revolutions per minute of feed pump	9
Revolutions per minute of circulating pump	200
Revolutions per minute of air pump	52
Temperature of feed heater, degrees F	220
Temperature of filter box, degrees F	110
Temperature of sea suction, degrees F	70
Temperature of condenser discharge, degrees F	102

Fig. 5.—Tug *Energy*, Built by Northwest Engineering Works

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10,000-Ton Oil Tank Steamship

Description of Vessels Building By Merchant Shipbuilding Corporation for Union Oil Company of California

THE Union Oil Company of California has ordered a fleet of four 10,000-ton oil tankers from the Merchant Shipbuilding Corporation, which are being built at the Chester, Pa., yard of this company. The vessels are of the steel single-screw type with the machinery aft. The hull is longitudinally framed on the Isherwood system. Cargo oil will be carried in nine main tanks and in four summer tanks on the port and starboard sides of the vessel.

The general design, as shown in the illustrations, calls for a vessel fitted with a long poop, short bridge, and forecastle arranged for crew accommodations, stores, etc. The officers are housed in a steel house on the bridge deck, the captain in a steel house on the boat deck, with a wooden wheel house and chart room above. The principal dimensions are as follows:

Length overall	439 feet 7 inches
Length between perpendiculars	424 feet
Beam, molded	58 feet
Depth at side to upper deck	33 feet
Draft. designed load	25 feet 5 inches
Displacement, at designed load draft	14,360 tons
Deadweight tonnage	10,000 tons
Speed, designed, at load draft	10½ knots
Deadweight, at designed load draft	10,000 tons
Cargo capacity, main tanks, including expansion trunk, about	380,000 cubic feet
Cargo capacity, summer tanks, about	55,000 cubic feet
Fuel oil capacity, at 38 cubic feet per ton, about	1,350 tons
Drinking water tanks, about	29 tons
Reserve feed water, about	200 tons
Package freight holds, bales, about	30,000 cubic feet

Hull Construction

As shown by the general plans a double bottom is fitted under the engine and boiler rooms only, and is used for

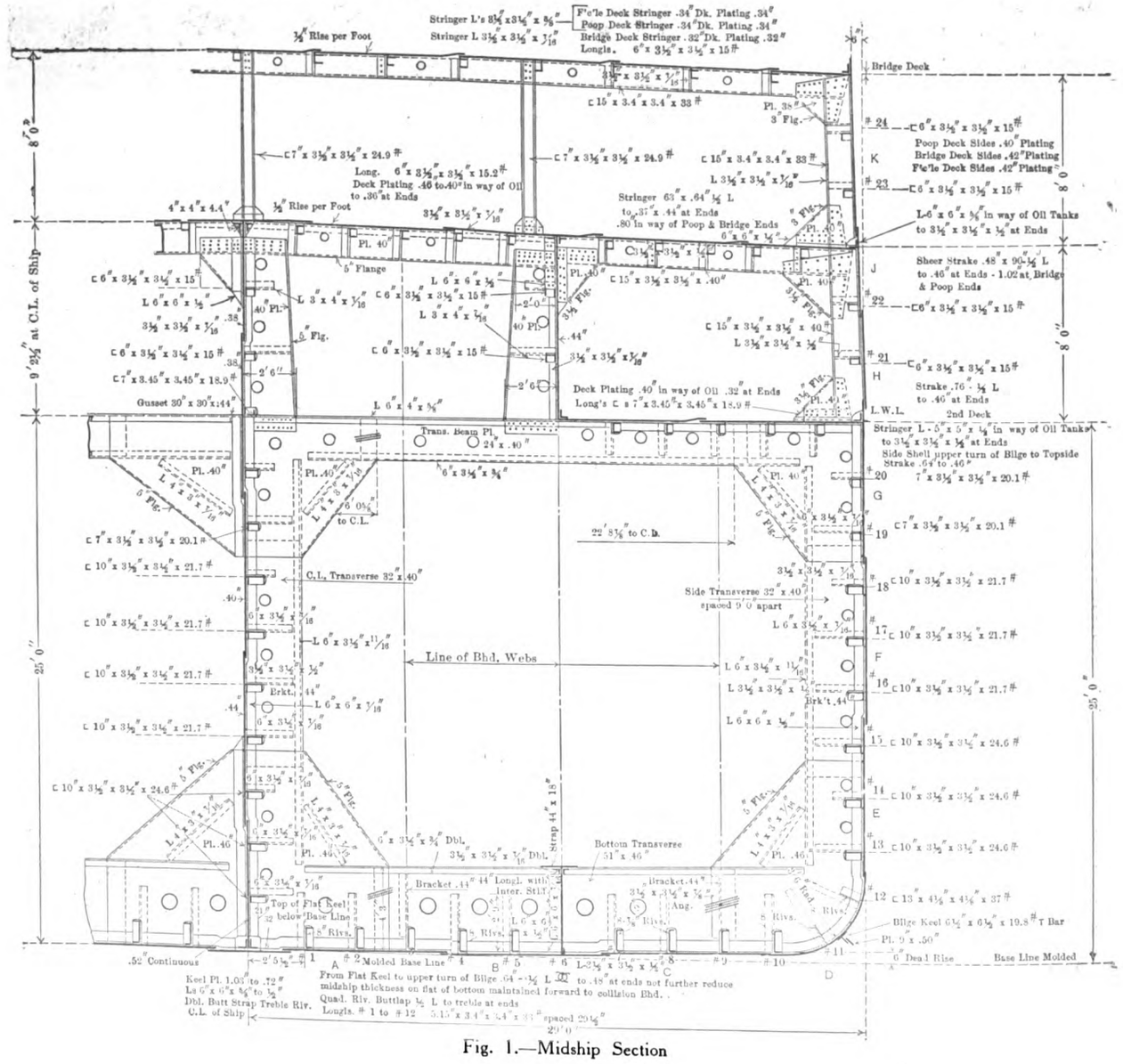

Fig. 1.—Midship Section

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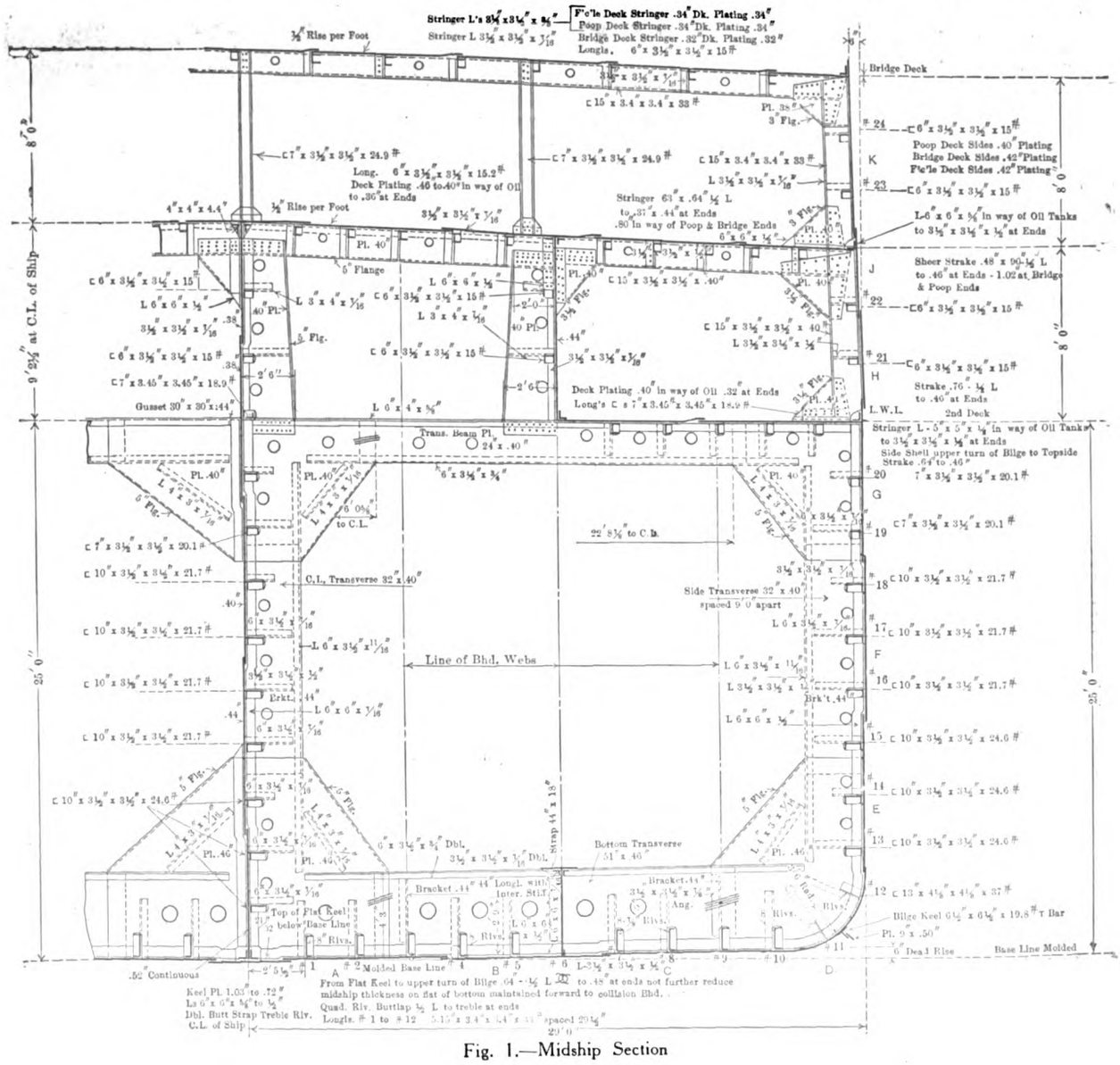
Bridge Deck
Poop Deck Sides .40" Plating
Bridge Deck Sides .42" Plating
Fc'le Deck Sides .42" Plating
Sheer Strake .48" x 90-½ L to .46" at Ends - 1.02" at Bridge & Poop Ends
Stringer L - 5" x 5" x ½" in way of Oil Tanks to 3½" x 3½" x ½" at Ends
Side Shell upper turn of Bilge to Topside Strake .64" to .46"
2nd Deck
L.W.L.
Line of Bhd. Webs
Side Transverse 32" x 40" spaced 9'0" apart
C.L. Transverse 32" x 40"
Trans. Beam Pl. 24" x .40"
Bottom Transverse 51" x 46"
Base Line Molded
Keel Pl. 1.03" to .72"
Dbl. Butt Strap Treble Riv.
C.L. of Ship
From Flat Keel to upper turn of Bilge .64" - ½ L to .48" at ends not further reduce midship thickness on flat of bottom maintained forward to collision Bhd.
Longls. # 1 to # 12 - 15" x 3.4" x 3.4" x 33# spaced 20½"

Fig. 1.—Midship Section

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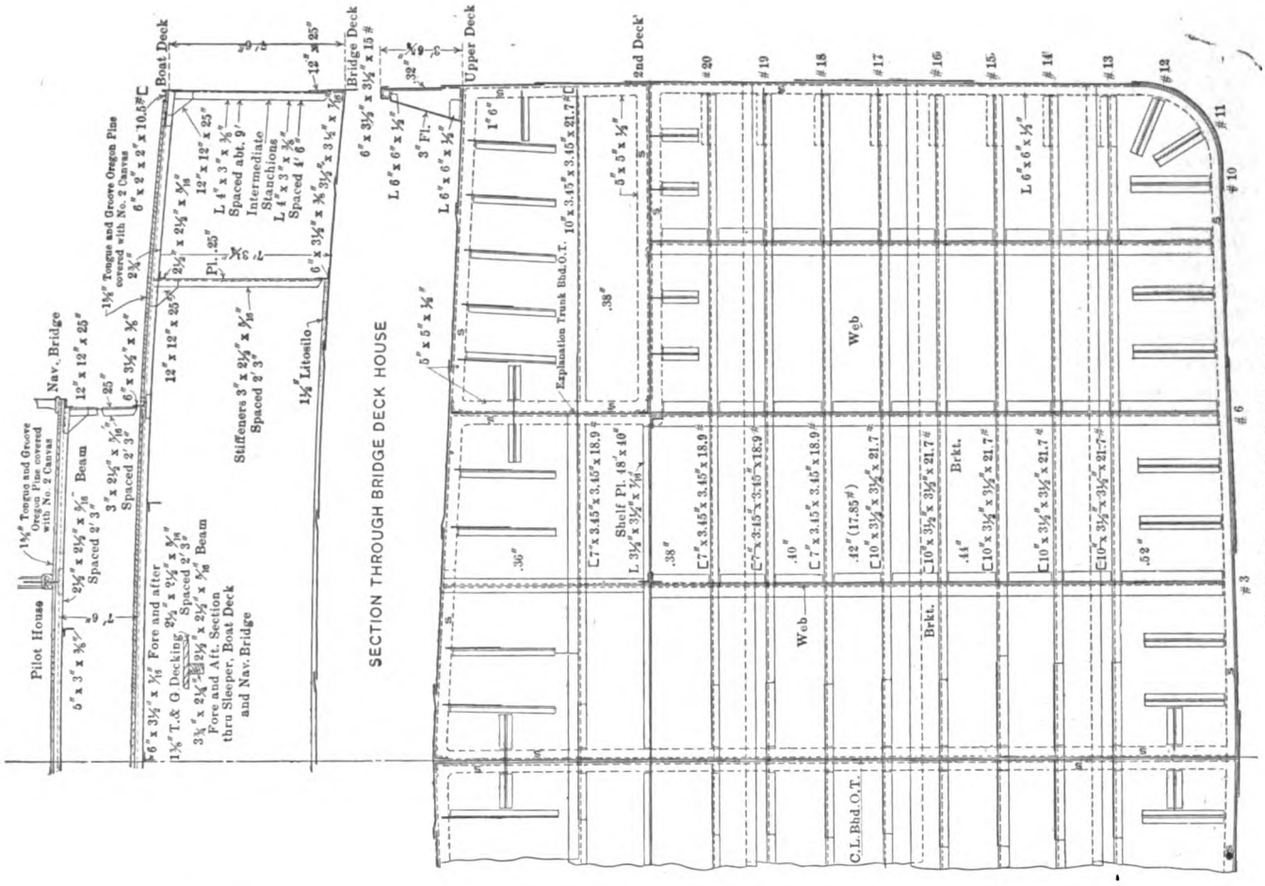

Fig. 8.—Typical Oil-Tight Bulkhead

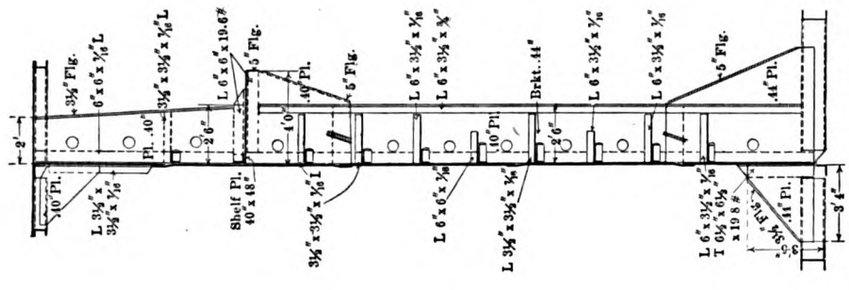

Fig. 7.—Inboard Vertical Stiffener

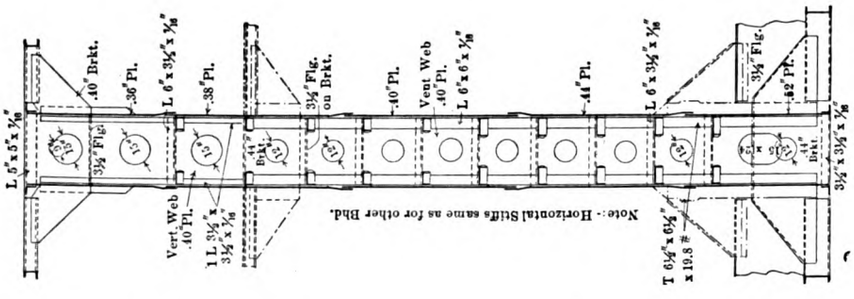

Fig. 6.—Cofferdam Bulkhead

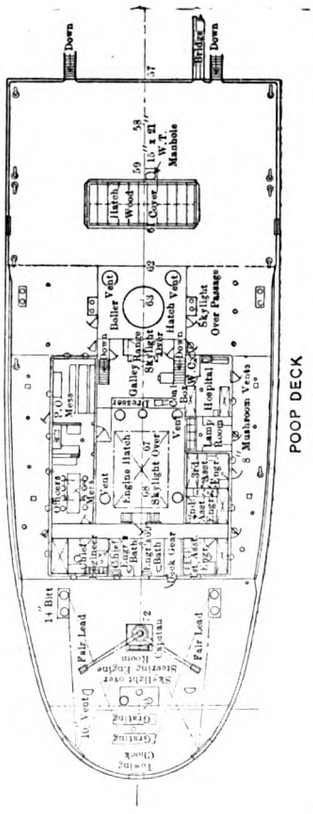

Fig. 5

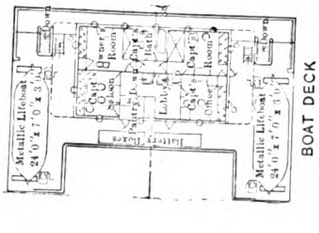

Fig. 3

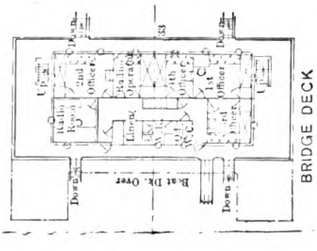

Fig. 4

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reserve feed water. The fuel oil is carried in a deep tank forward of the boiler room. This is separated from the aft cargo oil tanks by a cofferdam. Similarly the forward cargo oil tanks are separated by a cofferdam from the package freight hold, under which is a deep tank fitted for fuel oil or water ballast. The peak tanks are fitted for ballast. Additional package cargo space can be provided at the forward end of the poop. The main pump room is located between Nos. 4 and 5 main tanks, and a small pump room is located forward of the forward cofferdam between the oil-tight flat and the lower deck.

Hatches are provided for each oil tank and for the package holds forward and aft, as shown on the plans. The vessel is schooner-rigged with two steel pole masts. On the forward side of the foremast are fitted two five-ton wooden cargo booms, each 45 feet long. On the after side of the main mast is a single wooden cargo boom, 47 feet long, capable of lifting five tons.

The main scantlings of the hull are as shown on the midship section. The vertical keelson is continuous throughout from peak bulkhead to peak bulkhead and is oil-tight, except in the machinery spaces, where it is substantially tight. From the top of the vertical keel to the top of the tanks throughout the length of the cargo and fuel oil tanks extends an oil-tight centerline bulkhead.

A continuous expansion trunk is fitted between the second and upper decks for all main oil tanks. The trunk bulkheads extend through the after oil bunkers and are connected to the boiler casing.

Transverses are spaced as shown on the plan, generally 9 feet between centers. Under the boilers they are spaced 6 feet 9 inches with an intermediate transverse under the engine. Transverse floors are fitted in the peak tanks, spaced 24 inches between centers.

Electric Welding

In building the vessels the following parts may, at the builders' option and subject to the approval of the classification society, be electrically welded instead of riveted.

Gutter bars at oil bulkheads.

Clips and angles on bulkheads, etc., for engine and boiler room floor plates.

Bathroom, galley and miscellaneous fixtures.

Gasket angles, covers, etc., metal doors and covers.

Engine room and other metal skylights and covers.

Non-structural tanks.

Smokestack.

Uptakes.

Ventilator deck angles to vent cowls.

Bulkheads, trunks, etc., not forming part of the strength members of the vessel.

Slop chute.

Sheet metal work in general when of black iron.

Masts.

Two cold storage rooms are provided on the upper deck in the engine hatch. One of these is the meat room of about 550 cubic feet capacity, and the other the provision room of about 340 cubic feet capacity.

Propelling Machinery

Propulsion is by single-screw of the four-bladed built-up type, about 17 feet diameter, driven by a vertical inverted triple expansion surface condensing engine with cylinders 27 inches, 45 inches and 75 inches diameter by 51 inches stroke. The three cranks are set at angles of 120 degrees and the cylinders are arranged with the high pressure forward and the low pressure aft. The high and intermediate-pressure valves are of the piston type, while the low-pressure cylinder has a balanced slide valve.

The main condenser, which is independent of the main engine, has a cooling surface of 4,000 square feet. The main air pump, together with two bilge pumps, is driven direct from the low-pressure crosshead of the main engine. The circulating pump is of the centrifugal double-suction type of 5,500 gallons per minute capacity, driven by a vertical single-cylinder reciprocating engine, operating with steam at 100 pounds pressure.

The main crankshaft and crank pins are 15⅛ inches diameter; the thrust shaft 15¼ inches diameter under the collar, and the propeller shaft 15½ inches diameter.

Boilers

Steam will be supplied at a pressure of 200 pounds per square inch by three single-end Scotch boilers 15 feet 3 inches inside diameter by 11 feet 6 inches long over the heads, each with a total heating surface of 2,750 square feet. Each boiler has three Morrison corrugated furnaces, 45 inches inside diameter, leading to separate combustion chambers.

The boilers are fitted for burning oil and burners of the mechanical atomizing type will be fitted, having a total maximum capacity of 3,700 pounds of fuel oil per hour. The fuel oil is handled by two horizontal duplex double-acting pumps 5¼ inches by 3½ inches by 5 inches, with the suction connected to the after fuel oil deep tank, and the discharge (through fuel oil heaters and strainers) to the burners. A fuel-oil transfer and ballast pump is also fitted, with suction from the forward fuel tanks port and starboard, discharging to the after fuel tank. This pump is 7 inches by 7 inches by 10 inches. Steamheating coils are fitted in all fuel oil tanks, as well as in all cargo oil tanks.

A vertical donkey boiler 48 inches diameter by 96 inches high, with about 330 square feet of heating surface, is installed in the fire room. This boiler will burn coal and supply steam at a pressure of 100 pounds per square inch.

Auxiliaries

The engine and fireroom auxiliaries include a forced draft blower of the steel-plate type, with a capacity of 22,000 cubic feet of air per minute at 100 degrees Fahrenheit, direct connected to two single cylinder vertical engines, one on each side of the fan casing. Two feed pumps are provided of the vertical simplex double-acting type, 12 inches by 8 inches by 24 inches. The feed water heater has a capacity for heating 40,000 pounds of water per hour from 90 to 215 degrees Fahrenheit, with five pounds steam pressure on the shell.

The equipment also includes a 30-ton evaporator with a horizontal duplex double-acting feed pump 4½ inches by 4 inches by 4 inches, and a fresh water distiller with a capacity of 2,000 gallons per twenty-four hours, with circulating water at 80 degrees Fahrenheit.

The auxiliary condenser has 7,000 square feet of cooling surface, and is mounted on a combined air and circulating pump 10 inches by 12 inches by 12 inches by 12 inches.

The electric plant consists of two 10-kilowatt direct-connected generators, driven by vertical reciprocating engines. A 2-ton refrigerating machine of the ammonia type is installed.

The pumps also include the following: One fresh water pump, 4½ inches by 3¾ inches by 4 inches, horizontal duplex; one salt water sanitary, 6 inches by 6 inches by 10 inches, horizontal duplex; one donkey pump, 12 inches by 10 inches by 12 inches, horizontal duplex; one bilge, 6 inches by 5 inches by 6 inches, horizontal duplex; and one hand fire and bilge, 6 inches by 5¼ inches, single cylinder.

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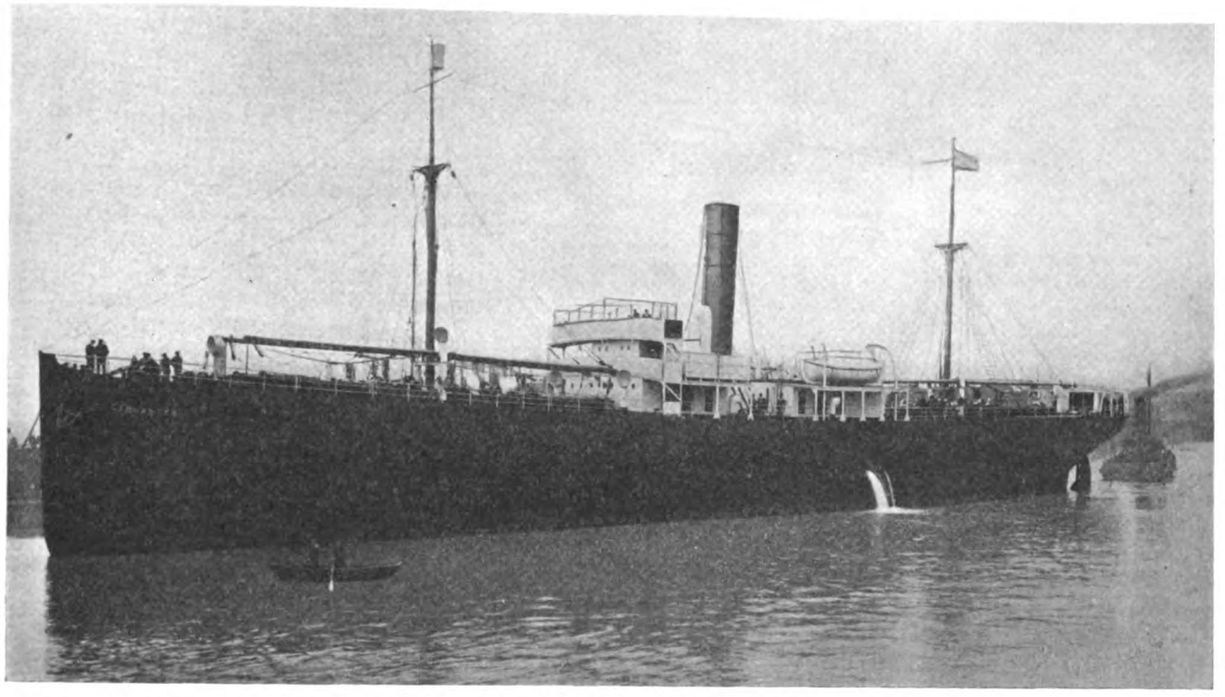

Fig. 1.—Eight Ships of the *Cervantes* Type Have Been Built in Great Britain in Pursuance of the Policy of Ship Standardization

British Standard Ship of 3,150 Tons D. W.

Cargo Ships of Standard Design Being Developed by the Shipbuilders in Great Britain to Replace War Losses in Vessel Tonnage

BY MAJOR FREDERICK C. COLEMAN

AS in the United States, the problems of ship standardization have received great attention in the United Kingdom for the past two or three years, and every effort has been made to place shipbuilding on the production basis so necessary quickly to replace the tonnage losses of the war. The entire programme of standard ship construction has been in the hands of the British Shipping Controller, who has enlisted the co-operation of practically every shipyard in the country. Fabricating processes have not reached the advanced stage that they have in the United States, but the number of standard ships turned out in British yards is increasing rapidly.

Among others who have given the matter of standardization special consideration is the firm of Messrs. H. & C. Grayson, Ltd., of Liverpool. Eight vessels of a single type have so far been built and delivered from the Liverpool yards of this company, and a large number are now on the ways. Five of the earlier vessels were acquired by the British Shipping Controller, and three of these, the *Cervantes*, the *Colon* and the *Ciscar*, were subsequently allocated to Messrs. R. MacAndrew & Company, Ltd., London.

Principal Dimensions of Cervantes Type

These vessels are of the shelter deck type, having the following principal dimensions:

Length overall	275 feet
Length between perpendiculars	265 feet
Breadth amidships	41 feet
Depth to upper deck	21 feet
Depth to shelter deck	28 feet 10 inches
Extreme draft	20 feet 2 inches
Deadweight capacity at above draft	3,150 tons
Block coefficient	0.75

Hold and Bunker Capacity

The total grain carrying capacity of each vessel is 176,126 cubic feet, which is divided between the fore and after holds and the fore and after 'tween decks. The total bunker capacity is 582 tons of coal, 254 tons of which is below the upper deck and the remainder on the 'tween decks and shoots. The water ballast in No. 1 double bottom is 207 tons; in No. 2 double bottom, port, 45.5 tons; No. 2 double bottom, starboard, 45.5 tons, and No. 3 double bottom, 110 tons, making a total of 408 tons in the double bottoms. Water ballast in the fore peak amounts to 63 tons, and in the aft peak to 17.5 tons, making a total water ballast of 488.5 tons. Tonnage under the deck amounts to 2,330 tons, while the gross tonnage is 2,436 and the net tonnage 1,508. These tonnages include the 'tween decks, the tonnage hatch having been built up as an ordinary hatch.

Double Bottom

The double bottom, 3 feet deep, is continuous from peak to peak, and is constructed on the cellular system with a solid floor on every frame. It is divided into three compartments, one under the fore hold, another under the engine and boiler room, and a third under the after hold. The compartment under the engine and boiler room is further divided by the watertight center girder. The peaks are also arranged to carry water ballast, or, when necessary, fresh water for boiler feed water.

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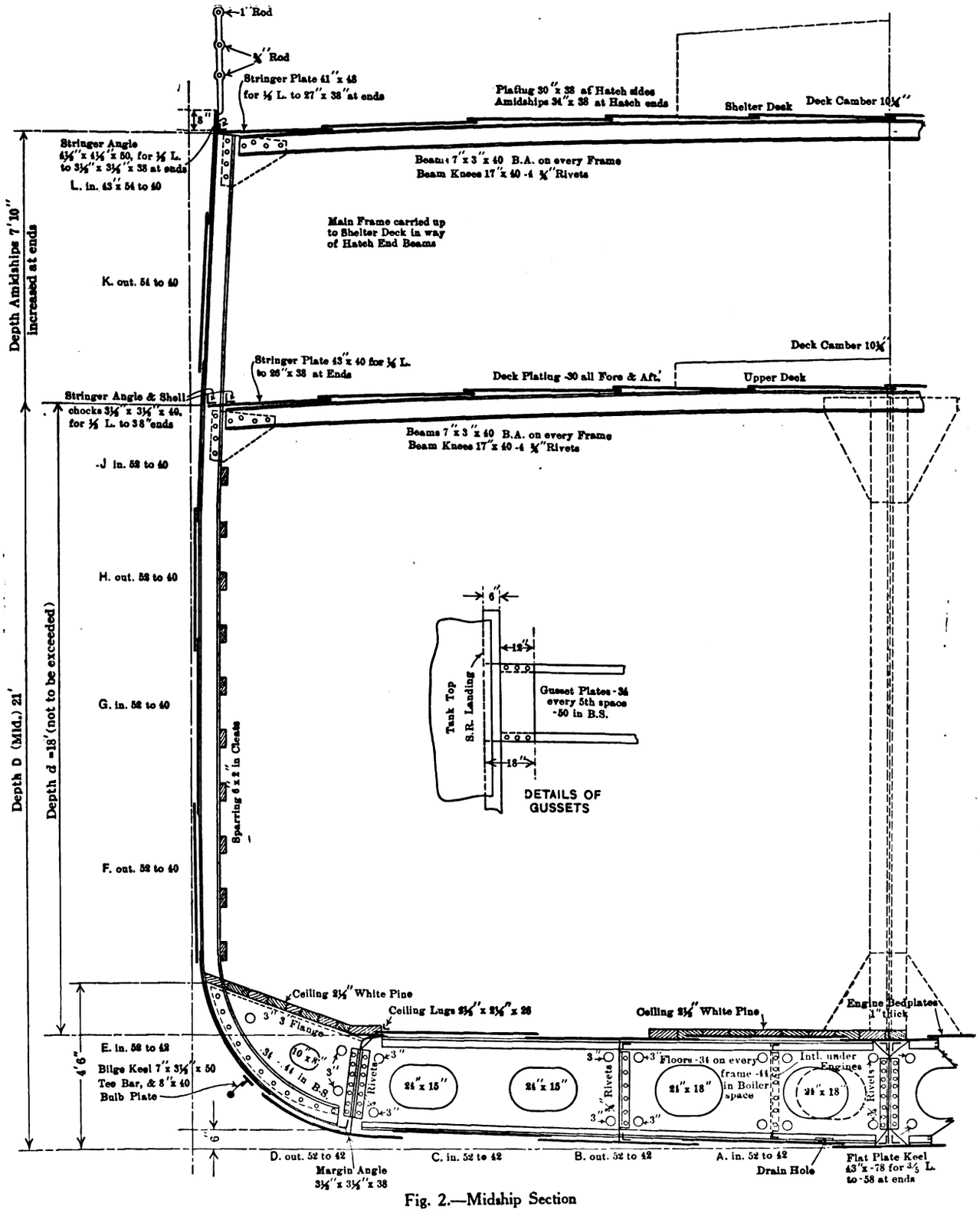
1" Rod
⅞" Rod
Stringer Plate 41" x 48 for ⅛ L. to 27" x 38" at ends
Plating 30" x 38 at Hatch sides Amidships 34" x 38 at Hatch ends
Shelter Deck
Deck Camber 10¼"
Stringer Angle 4½" x 4½" x 50, for ⅛ L. to 3½" x 3½" x 38 at ends
L. in. 43" x 54 to 40
Beams 7" x 3" x 40 B.A. on every Frame
Beam Knees 17" x 40 -4 ⅞" Rivets
Main Frame carried up to Shelter Deck in way of Hatch End Beams
Depth Amidships 7' 10" increased at ends
K. out. 54 to 40
Stringer Plate 43" x 40 for ⅛ L. to 26" x 38 at Ends
Deck Plating -30 all Fore & Aft.
Upper Deck
Deck Camber 10¼"
Stringer Angle & Shell chocks 3½" x 3½" x 40. for ⅛ L. to 36" ends
Beams 7" x 3" x 40 B.A. on every Frame
Beam Knees 17" x 40 -4 ⅞" Rivets
J in. 52 to 40
H. out. 52 to 40
G. in. 52 to 40
Depth D (Mid.) 21'
Depth d =18' (not to be exceeded)
Sparring 6 x 2 in Clear
F. out. 52 to 40
6"
12"
Tank Top
S.R. Landing
Gusset Plates -36 every 5th space -50 in B.S.
18"
DETAILS OF GUSSETS
Ceiling 2½" White Pine
Ceiling Lugs 2½" x 2½" x 26
Ceiling 2½" White Pine
Engine Bedplates 1" thick
3" x 3" Flange
E. in. 52 to 42
4'6"
Bilge Keel 7" x 3½" x 50
Tee Bar, & 8" x 40
Bulb Plate
10" x ⅝" 34 -44 in B.S.
3" Rivets
24" x 15"
24" x 15"
Floors -34 on every frame -44 in Boiler space
21" x 18"
Intl. under Engines
21" x 18"
¾" Rivets
6"
D. out. 52 to 42
C. in. 52 to 42
B. out. 52 to 42
A. in. 52 to 42
Margin Angle 3½" x 3½" x 38
Drain Hole
Flat Plate Keel 43" x -78 for ⅛ L. to -58 at ends

Fig. 2.—Midship Section

The vessels are divided into five watertight compartments, with a cross bunker forward of the boiler space. The forepeak bulkhead extends to the shelter deck and the others to the upper deck, the engine and boiler room bulkheads being extended to the shelter deck, forming 'tween deck bunker ends. There are two pocket bunkers on each side of the engine room, a cross bunker forward of the stokehold, and 'tween deck bunkers abreast of the engine and boiler room casings.

Two hatchways give access to each hold, those in No. 1 forehold being 24 feet by 12 feet 6 inches and 26 feet by 12 feet 6 inches, respectively, and those in No. 2 after hold 22 feet by 12 feet 6 inches and 20 feet by 12 feet 6 inches.

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A chart house built of steel, situated on the bridge deck, is subdivided to provide a chart room and accommodation for the captain. A deck house is erected on the boat deck, and provides a wireless cabin and accommodations

(*Concluded on page* 380.)

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Vessels Built in the United States in 1919

Shipyard	Number of Ships	Total Dead-weight Tonnage	Total Horse-power
Wm. G. Abbott Shipbuilding Company	5	.....	.....
Alabama Dry Dock & Shipbuilding Company.	5	21,200	8,100
Albina Engine & Machine Works, Inc.	8	29,600	11,200
Allen Shipbuilding Company	3	10,950	1,400
American Bridge Company	55	.....	.....
American Car & Foundry Company	6	2,976	600
American International Shipbuilding Corpn.	69	500,800	172,500
American Lumber Company	1	2,500	.....
American Shipbuilding Company (Cleveland)	98	399,600	135,600
American Shipbuilding Co. (Brunswick, Ga.)	5	12,500	7,000
Ames Shipbuilding & Dry Dock Company	12	105,600	35,200
Atlantic Corporation	4	35,200	11,200
Atlantic, Gulf & Pacific Company	8	1,750	.....
William H. Baldwin	2	253	.....
Baltimore Dry Docks & Shipbuilding Co.	15	85,425	29,500
Bangor Shipbuilding Corporation	1	1,500	.....
Barbare Brothers	3	10,500	1,400
Bath Iron Works	4	4,800	96,800
Bayles Shipyard, Inc.	7	22,400	8,800
Beaumont Shipbuilding & Dry Dock Co.	5	17,500	7,000
Benicia Shipbuilding Corporation	3	10,500	.....
A. Bentley & Sons Company	1	7,500	2,800
Bethlehem Shipbuilding Corporation, Ltd.:			
Fore River plant	40	113,152	549,040
Squantum plant	29	35,525	783,000
Moore plant	21	10,940	16,200
Harlan plant	6	37,800	12,150
Sparrows Point plant	11	103,000	29,900
Potrero Works	17	20,185	729,000
Alameda Works	10	111,200	29,200
Total	134	431,802	2,148,490
Bowker Ship Yard	2	1,452	.....
A. C. Brown & Sons	1	.....	.....
Burger Boat Building Company	8	.....	4,500
Carolina Ship Building Corporation	7	67,200	19,600
Chance Marine Construction Company	3	501	1,360
R. J. Chandler Shipbuilding Company	1	3,500	1,400
Chicago Bridge & Iron Works	8	4,000	.....
Coast Shipbuilding Company	5	17,500	7,000
Coastwise Shipbuilding Company	3	7,500	.....
Frances Cobb Shipbuilding Company	1	2,500	.....
Columbia River Shipbuilding Corporation	16	166,400	43,600
Consolidated Shipbuilding Corporation	2	2,000	2,800
Continental Shipbuilding Corporation	1	1,500	.....
Coos Bay Shipbuilding Company	7	15,500	1,400
Wm. Cramp & Sons Ship & Engine Bldg. Co.	22	52,155	541,000
H. E. Crook Company	2	5,000	.....
Crosby Navigation Company	2	5,000	.....
Crowell & Thurlow	10	18,800	.....
Crowninshield Shipbuilding Company	5	.....	4,250
Cumberland Shipbuilding Company	8	28,000	11,200
Dachel-Carter Shipbuilding Company	3	448	975
Oscar Daniels Company	5	47,500	14,000
Dantzler Shipbuilding & Dry Dock Co., Inc.	4	14,000	2,800
M. M. Davis & Sons, Inc.	5	.....	.....
G. G. Deering Company	1	3,500	.....
Dierks-Blodgett Shipbuilding Company	5	17,500	.....
Doullut & Williams Shipbuilding Company	2	19,200	5,600
Downey Shipbuilding Corporation	9	70,200	22,500
The Dravo Contracting Company	28	21,380	1,500
Dubuque Boat & Iron Works	5	8,500	1,700
	5	.....	800
Dunn & Elliott Company	2	3,900	.....
J. F. Duthie & Company	10	88,000	28,000
East Coast Ship Company	2	2,200	.....
Federal Shipbuilding Company	27	261,900	67,500
Feeney & Bremer Company	1	3,500	.....
Ferguson Steel & Iron Company	21	12,200	9,000
Fougner Shipbuilding Company	1	3,500	1,400
The Foundation Company	51	72,600	40,200
Freeport Shipbuilding Company	2	7,000	2,800
Fry Flynn Company	2	3,600	.....
Fulton Shipbuilding Company	5	18,500	4,200
Gibbs Gas Engine Company	2	.....	.....
George A. Gilchrist	1	3,500	1,400
Gildersleeve Ship Construction Company	2	7,000	1,400
Globe Shipbuilding Company	10	38,750	13,750
Grays Harbor Motorship Corporation	6	19,500	11,200
Great Lakes Engineering Works	40	167,600	57,000
Richard T. Green Company	1	2,500	.....
Greenport Basin & Construction Company	9	10,113	650
Groton Iron Works (Noank)	2	7,000	.....
Groton Iron Works	6	52,800	15,000
Hammond Lumber Company	5	17,500	2,800
Hampton Shipbuilding & Dry Dock Corpn.	2	7,000	.....
Hanlon Dry Dock & Shipbuilding Company	2	10,700	3,600
Louis B. Harrison Shipyards, Inc.	6	9,600	.....
Heldenfels Brothers	2	7,000	.....
Hodge Ship Company	1	3,500	1,400
Houstonic Shipbuilding Company	6	21,000	1,400
Hulfin Boat Company	1	40	28
International Shipbuilding & Marine Engineering Corporation	2	.....	.....
Jahncke Shipbuilding Corporation	4	14,000	5,600
John F. James & Son	2	281	300
Johnson Iron Works, Ltd.	12	1,670	7,554
Johnson Shipyards Corporation	4	13,000	1,400
Kelly-Spear Company	3	8,500	1,400
Kingston Shipbuilding Company	2	7,000	2,800
Kruse & Banks Shipbuilding Company	4	14,000	.....
Kyle & Purdy, Inc.	6	2,550	5,100

Shipyard	Number of Ships	Total Dead-weight Tonnage	Total Horse-power
Lake Torpedo Boat Company	8	.....	.....
Leatham & Smith Towing & Wrecking Co.	5	.....	2,250
Fred T. Ley & Company, Inc.	2	17,000	5,600
Liberty Shipbuilding Company	1	3,000	1,400
Lone Star Shipbuilding Company	5	17,500	5,200
Long Beach Shipbuilding Company	6	44,400	14,700
Los Angeles Shipbuilding & Dry Dock Co.	10	88,000	35,000
McAteer Ship Building Company	2	5,000	500
McBride & Law	2	7,000	2,800
J. N. McCammon	2	7,400	.....
McDougall-Duluth Company	17	65,600	23,250
McEachern Ship Company	9	31,500	8,400
Machias Ship Construction Company	3	7,500	.....
Manistee Shipbuilding Company	1	3,750	.....
Manitowoc Ship Building Company	13	48,750	.....
Maryland Shipbuilding Company	4	14,000	2,800
J. H. Mathis Company	1	.....	.....
Meacham & Babcock	10	35,000	5,600
Merchant Shipbuilding Corporation	28	248,400	81,500
Merrill-Stevens Shipbuilding Corporation	2	12,000	4,000
Midland Bridge Company	10	34,100	8,400
Missouri Bridge & Iron Company	2	7,000	.....
Mobile Shipbuilding Company	7	27,500	9,950
Moore Shipbuilding Company	16	151,000	44,800
Morey & Thomas	3	10,500	2,800
J. W. Murdoch	2	7,000	1,400
Murnan Shipbuilding Company	2	7,000	.....
Nashville Bridge Company	3	5,400	.....
National Ship Building Company	10	50,000	14,500
National Shipbuilding Corporation	2	7,500	2,250
Newburgh Shipyards	7	61,754	19,600
Newcastle Shipbuilding Company	2	5,000	.....
Newport News Shipbuilding & Dry Dock Co.	12	50,925	226,600
Newport Shipbuilding Company	3	1,500	1,800
New York Shipbuilding Corporation	16	65,050	299,850
Nilson & Kelez Shipbuilding Corporation	3	10,500	1,400
North Carolina Shipbuilidng Company	2	7,000	.....
Northwest Engineering Works	15	2,945	10,000
Northwest Steel Company	18	158,400	47,400
Pacific American Fisheries	3	10,500	4,500
Pacific Coast Shipbuilding Company	3	28,200	9,600
Pacific Marine Construction Company	2	15,000	5,600
Peninsula Shipbuilding Company	4	16,000	6,000
Pensacola Shipbuilding Company	4	36,000	12,000
Percy & Small, Inc.	2	2,860	.....
Providence Engineering Corporation	6	.....	4,800
Puget Sound Bridge & Dredging Company	4	18,000	2,800
Pusey & Jones Company	15	107,200	32,230
Rolph Shipbuilding Company	3	10,500	.....
Russell Shipbuilding Company	2	7,000	.....
George D. Ryan & Son	7	1,785	225.
Saginaw Shipbuilding Company	8	28,000	11,600
St. Helens Shipbuilding Company	3	10,500	1,400
St. John's River Shipyard Company	8	25,000	.....
Sanderson & Porter	10	35,000	1,400
Sandy Point Shipbuilding Company	4	12,000	.....
San Francisco Shipbuilding Company	1	2,500	2,800
Seaboard Transportation & Shipping Co.	2	400	400
Seaborn Shipyards	6	21,000	2,800
Seattle Construction & Drydock Company	6	45,000	14,400
Seattle North Pacific Shipbuilding Company.	10	94,000	28,000
L. H. Shattuck, Inc.	14	49,000	11,800
The Ship Construction & Trading Co., Inc.	3	10,000	1,400
Skinner & Eddy Corporation	33	326,000	90,500
Sloan Shipyards Corporation	8	28,000	7,000
Grant Smith-Porter Ship Company	25	87,500	25,200
Henry Smith & Sons Company	2	7,000	.....
Sommarstrom Shipbuilding Company	7	24,500	8,400
Southern Dry Dock & Shipbuilding Company.	5	17,500	.....
Southand Steamship Company	7	.....	6,300
Southwestern Shipbuilding Company	9	79,200	25,200
Standard Shipbuilding Corporation	10	74,000	25,000
G. M. Standifer Construction Corporation	22	121,900	16,800
Staten Island Shipbuilding Company	11	3,500	17,600
Stockton Yard, Inc.	2	4,000	.....
Story's Ship Yard	5	1,385	625
Submarine Boat Corporation	95	508,250	142,500
John W. Sullivan	1	.....	.....
Sun Shipbuilding Company	10	112,349	38,000
Supple-Ballin Shipbuilding Corporation	6	25,500	9,300
Tacoma Shipbuilding Company	6	21,000	2,800
Tampa Dock Company	3	10,500	2,800
Tampa Shipbuilding & Engineering Company.	2	7,000	.....
Tank-Ship Building Corporation	2	3,500	1,000
C. H. Tenney & Company	2	7,000	.....
Terry Shipbuilding Corporation	6	21,000	8,400
Texas Steamship Company	14	44,489	13,500
Thames Towboat Company	1	197	500
Todd Dry Dock & Construction Corporation.	11	84,700	28,100
Todd Shipyards Corporation	16	73,000	31,400
Toledo Shipbuilding Company	12	46,950	17,100
Traylor Shipbuilding Corporation	3	10,500	4,200
E. James Tull	1	470	.....
Union Construction Company	3	28,650	8,400
United States Maritime Corporation	3	10,500	4,200
Universal Shipbuilding Company	3	10,500	5,200
Vinyard Shipbuilding Company	1	.....	.....
Virginia Shipbuilding Corporation	5	47,000	14,000
Western Pipe & Steel Company	10	88,000	25,000
Whitehaven Shipbuilding Company	2	5,000	.....
Whitney Brothers Company	10	4,234	9,500
Wilson Shipbuilding Company	4	14,000	1,400
Wright Shipbuilding Company	4	14,000	1,400
York River Shipbuilding Company	5	7,000	.....

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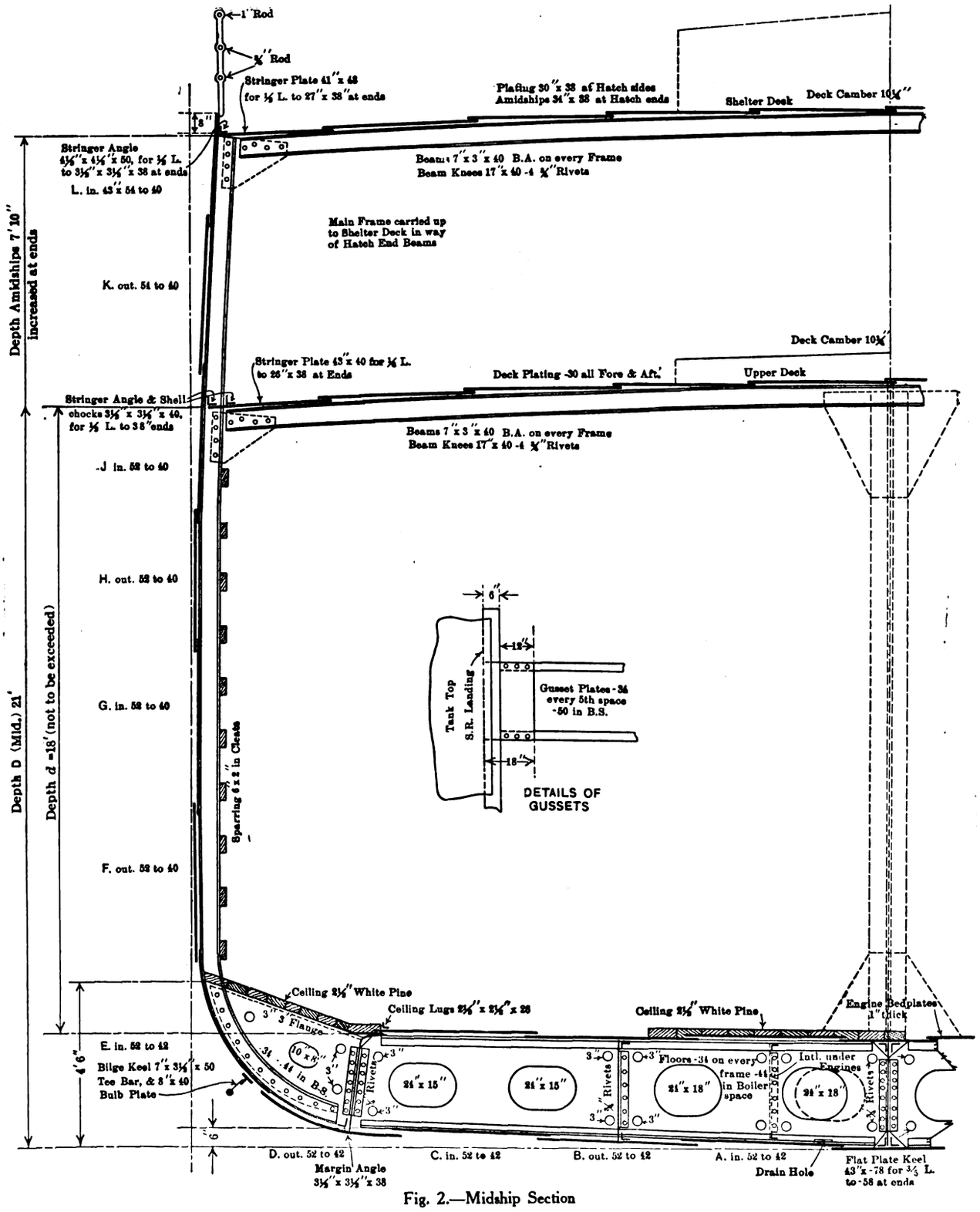
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Fig. 2.—Midship Section

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Coast Shipbuilding Company	5	17,500	7,000
Coastwise Shipbuilding Company	3	7,500	.....
Frances Cobb Shipbuilding Company	1	2,500	.....
Columbia River Shipbuilding Corporation	16	166,400	43,600
Consolidated Shipbuilding Corporation	2	2,000	2,800
Continental Shipbuilding Corporation	1	1,500	.....
Coos Bay Shipbuilding Company	7	15,500	1,400
Wm. Cramp & Sons Ship & Engine Bldg. Co.	22	52,155	541,000
H. E. Crook Company	2	5,000	.....
Crosby Navigation Company	2	5,000	.....
Crowell & Thurlow	10	18,800	.....
Crowninshield Shipbuilding Company	5	.....	4,250
Cumberland Shipbuilding Company	8	28,000	11,200
Dachel-Carter Shipbuilding Company	3	448	975
Oscar Daniels Company	5	47,500	14,000
Dantzler Shipbuilding & Dry Dock Co., Inc.	4	14,000	2,800
M. M. Davis & Sons, Inc.	5	.....	.....
G. G. Deering Company	1	3,500	.....
Dierks-Blodgett Shipbuilding Company	5	17,500	.....
Doullut & Williams Shipbuilding Company	2	19,200	5,600
Downey Shipbuilding Corporation	9	70,200	22,500
The Dravo Contracting Company	28	21,380	1,500
Dubuque Boat & Iron Works	5	8,500	1,700
	5	.....	800
Dunn & Elliott Company	2	3,900	.....
J. F. Duthie & Company	10	88,000	28,000
East Coast Ship Company	2	2,200	.....
Federal Shipbuilding Company	27	261,900	67,500
Feeney & Bremer Company	1	3,500	.....
Ferguson Steel & Iron Company	21	12,200	9,000
Fougner Shipbuilding Company	1	3,500	1,400
The Foundation Company	51	72,600	40,200
Freeport Shipbuilding Company	2	7,000	2,800
Fry Flynn Company	2	3,600	.....
Fulton Shipbuilding Company	5	18,500	4,200
Gibbs Gas Engine Company	2	.....	.....
George A. Gilchrist	1	3,500	1,400
Gildersleeve Ship Construction Company	2	7,000	1,400
Globe Shipbuilding Company	10	38,750	13,750
Grays Harbor Motorship Corporation	6	19,500	11,200
Great Lakes Engineering Works	40	167,600	57,000
Richard T. Green Company	1	2,500	.....
Greenport Basin & Construction Company	9	10,113	650
Groton Iron Works (Noank)	2	7,000	.....
Groton Iron Works	6	52,800	15,000
Hammond Lumber Company	5	17,500	2,800
Hampton Shipbuilding & Dry Dock Corpn.	2	7,000	.....
Hanlon Dry Dock & Shipbuilding Company	2	10,700	3,600
Louis B. Harrison Shipyards, Inc.	6	9,600	.....
Heldenfels Brothers	2	7,000	.....
Hodge Ship Company	1	3,500	1,400
Housatonic Shipbuilding Company	6	21,000	1,400
Hulfin Boat Company	1	40	28
International Shipbuilding & Marine Engineering Corporation	2	.....	.....
Jahncke Shipbuilding Corporation	4	14,000	5,600
John E. James & Son	2	281	300
Johnson Iron Works, Ltd.	12	1,670	7,554
Johnson Shipyards Corporation	4	13,000	1,400
Kelly-Spear Company	3	8,500	1,400
Kingston Shipbuilding Company	2	7,000	2,800
Kruse & Banks Shipbuilding Company	4	14,000	.....
Kyle & Purdy, Inc.	6	2,550	5,100

Shipyard	Number of Ships	Total Dead-weight Tonnage	Total Horse-power
Lake Torpedo Boat Company	8	.....	.....
Leatham & Smith Towing & Wrecking Co.	5	.....	2,250
Fred T. Ley & Company, Inc.	2	17,000	5,600
Liberty Shipbuilding Company	1	3,000	1,400
Lone Star Shipbuilding Company	5	17,500	5,200
Long Beach Shipbuilding Company	6	44,400	14,700
Los Angeles Shipbuilding & Dry Dock Co.	10	88,000	35,000
McAteer Ship Building Company	2	5,000	500
McBride & Law	2	7,000	2,800
J. N. McCammon	2	7,400	.....
McDougall-Duluth Company	17	65,600	23,250
McEachern Ship Company	9	31,500	8,400
Machias Ship Construction Company	3	7,500	.....
Manistee Shipbuilding Company	1	3,750	.....
Manitowoc Ship Building Company	13	48,750	.....
Maryland Shipbuilding Company	4	14,000	2,800
J. H. Mathis Company	1	.....	.....
Meacham & Babcock	10	35,000	5,600
Merchant Shipbuilding Corporation	28	248,400	81,500
Merrill-Stevens Shipbuilding Corporation	2	12,000	4,000
Midland Bridge Company	10	34,100	8,400
Missouri Bridge & Iron Company	2	7,000	.....
Mobile Shipbuilding Company	7	27,500	9,950
Moore Shipbuilding Company	16	151,000	44,800
Morey & Thomas	3	10,500	2,800
J. W. Murdoch	2	7,000	1,400
Murnan Shipbuilding Company	2	7,000	.....
Nashville Bridge Company	3	5,400	.....
National Ship Building Company	10	50,000	14,500
National Shipbuilding Corporation	2	7,500	2,250
Newburgh Shipyards	7	61,754	19,600
Newcastle Shipbuilding Company	2	5,000	.....
Newport News Shipbuilding & Dry Dock Co.	12	50,925	226,600
Newport Shipbuilding Company	3	1,500	1,800
New York Shipbuilding Corporation	16	65,050	299,850
Nilson & Kelez Shipbuilding Corporation	3	10,500	1,400
North Carolina Shipbuilding Company	2	7,000	.....
Northwest Engineering Works	15	2,945	10,000
Northwest Steel Company	18	158,400	47,400
Pacific American Fisheries	3	10,500	4,500
Pacific Coast Shipbuilding Company	3	28,200	9,600
Pacific Marine Construction Company	2	15,000	5,600
Peninsula Shipbuilding Company	4	16,000	6,000
Pensacola Shipbuilding Company	4	36,000	12,000
Percy & Small, Inc.	2	2,860	.....
Providence Engineering Corporation	6	.....	4,800
Puget Sound Bridge & Dredging Company	4	18,000	2,800
Pusey & Jones Company	15	107,200	32,250
Rolph Shipbuilding Company	3	10,500	.....
Russell Shipbuilding Company	2	7,000	.....
George D. Ryan & Son	7	1,785	225
Saginaw Shipbuilding Company	8	28,000	11,600
St. Helens Shipbuilding Company	3	10,500	1,400
St. John's River Shipyard Company	8	25,000	.....
Sanderson & Porter	10	35,000	1,400
Sandy Point Shipbuilding Company	4	12,000	.....
San Francisco Shipbuilding Company	1	2,500	2,800
Seaboard Transportation & Shipping Co.	2	400	400
Seaborn Shipyards	6	21,000	2,800
Seattle Construction & Drydock Company	6	45,000	14,400
Seattle North Pacific Shipbuilding Company	10	94,000	28,000
L. H. Shattuck, Inc.	14	49,000	11,800
The Ship Construction & Trading Co., Inc.	3	10,000	1,400
Skinner & Eddy Corporation	33	326,000	90,500
Sloan Shipyards Corporation	8	28,000	7,000
Grant Smith-Porter Ship Company	25	87,500	25,200
Henry Smith & Sons Company	2	7,000	.....
Sommarstrom Shipbuilding Company	7	24,500	8,400
Southern Dry Dock & Shipbuilding Company.	5	17,500	.....
Southand Steamship Company	7	.....	6,300
Southwestern Shipbuilding Company	9	79,200	25,200
Standard Shipbuilding Corporation	10	74,000	25,000
G. M. Standifer Construction Corporation	22	121,900	16,800
Staten Island Shipbuilding Company	11	3,500	17,600
Stockton Yard, Inc.	2	4,000	.....
Story's Ship Yard	5	1,385	625
Submarine Boat Corporation	95	508,250	142,500
John W. Sullivan	1	.....	.....
Sun Shipbuilding Company	10	112,349	38,000
Supple-Ballin Shipbuilding Corporation	6	25,500	9,300
Tacoma Shipbuilding Company	6	21,000	2,800
Tampa Dock Company	3	10,500	2,800
Tampa Shipbuilding & Engineering Company.	2	7,000	.....
Tank-Ship Building Corporation	2	3,500	1,000
C. H. Tenney & Company	2	7,000	.....
Terry Shipbuilding Corporation	6	21,000	8,400
Texas Steamship Company	14	44,489	13,500
Thames Towboat Company	1	197	500
Todd Dry Dock & Construction Corporation.	11	84,700	28,100
Todd Shipyards Corporation	16	73,000	31,400
Toledo Shipbuilding Company	12	46,950	17,100
Traylor Shipbuilding Corporation	3	10,500	4,200
E. James Tull	1	470	.....
Union Construction Company	3	28,650	8,400
United States Maritime Corporation	3	10,500	4,200
Universal Shipbuilding Company	3	10,500	5,200
Vinyard Shipbuilding Company	1	.....	.....
Virginia Shipbuilding Corporation	5	47,000	14,000
Western Pipe & Steel Company	10	88,000	25,000
Whitehaven Shipbuilding Company	2	5,000	.....
Whitney Brothers Company	10	4,234	9,500
Wilson Shipbuilding Company	4	14,000	1,400
Wright Shipbuilding Company	4	14,000	1,400
York River Shipbuilding Company	3	7,000	.....

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Vessels Building in American Shipyards

OWNER	TYPE	DEADWEIGHT TONNAGE*	HORSE-POWER	NO. OF VESSELS	TOTAL DEAD-WEIGHT TONNAGE
	Alabama Dry Dock & Shipbuilding Company, Mobile, Ala.				
Panama Railroad	Coal Barges	7,500	.....	2	15,000
	American Bridge Company, Pittsburgh, Pa.				
United States Government	Barges	.....	.....	8	.....
Standard Oil Company of Louisiana	Oil Barges	.....	.....	7	.....
Standard Coal Company of California	Fuel Barges	.....	.....	2	.....
Sinclair Navigation Company, New York	Oil Barges	.....	.....	4	.....
Mexican Petroleum Corporation, Tampico, Mexico	Oil Barges	.....	.....	4	.....
Missouri Portland Cement Company	Sand Barges	.....	.....	3	.....
	American Car & Foundry Company, Wilmington, Del.				
United States Government	15-Car Float	.....	.....	1	.....
United States Government	10-Car Float	.....	.....	3	.....
Builder	4-Masted Schooners (length 210 ft.)	.....	.....	3	.....
	American International Shipbuilding Corporation, Hog Island, Pa.				
United States Shipping Board	Freighters	7,825	2,500	41	340,825
United States Army	Transports	9,300	6,000	10	93,000
	American Shipbuilding Company, Cleveland Ohio				
Pittsburgh Steel Company	Freighters	4,500	.....	4	18,000
United States Shipping Board	Cargo	4,200	1,500	9	37,800
	Ames Shipbuilding & Drydock Company, Portland, Ore.				
United States Shipping Board	Cargo	8,800	2,800	3	26,400
	Atlantic Coast Company, Thomaston, Maine				
Atlantic Coast Company, Boston, Mass.	4-Masted Schooners	2,000	.....	6	12,600
	Atlantic Corporation, Portsmouth, N. H.				
United States Shipping Board	Cargo	8,800	2,800	6	52,800
	Atlantic, Gulf & Pacific Company, Brooklyn, N. Y.				
United States Navy	Coal Barges	250	.....	7	1,750
United States Shipping Board	Dry Dock Sections	2,000	.....	14	28,000
	Baltimore Dry Dock & Ship Building Company, Baltimore, Md.				
United States Shipping Board	Tankers	10,000	2,700	5	50,000
United States Shipping Board	Tankers	6,000	1,800	3	18,000
Builder	Freighters	.....	.....	2	.....
	Bath Iron Works, Ltd., Bath, Maine				
Crowell & Thurlow, Boston, Mass.	Cargo	13,000	.....	1	13,000
Crowell & Thurlow, Boston, Mass.	Cargo	7,000	2,200	1	7,000
United States Navy	Destroyers	1,200	26,200	4	4,800
	Bayles Shipyards, Inc., Port Jefferson, N. Y.				
United States Shipping Board	Cargo	5,000	1,600	3	15,000
	Beaumont Ship Building & Dry Dock Company, Beaumont, Texas				
.....	Schooners	2,000	.....	2	4,000
United States Shipping Board	Barge	2,000	.....	1	2,000
	A. Bentley & Sons Company, Jacksonville, Fla.				
United States Shipping Board	Concrete Tanker	7,500	2,800	2	15,000
	Bethlehem Shipbuilding Corporation, Ltd., Bethlehem, Pa. Union Plant, San Francisco, Cal. (Protrero Works)				
United States Navy	Destroyers	1,185	27,000	2	2,370
United States Navy	Destroyers	1,225	27,000	39	47,775
United States Navy	Submarines	854	1,200	12	10,248
United States Shipping Board	Cargo	11,800	3,000	3	35,400
Pan-American Petroleum Company, Los Angeles, Cal.	Tankers	10,200	2,700	3	30,600
Standard Oil Company of California, San Francisco, Cal.	Tanker	12,800	3,000	1	12,800
	Union Plant, San Francisco, Cal. (Alameda Works)				
United States Shipping Board	Tankers	10,100	2,800	14	141,400
Standard Transportation Company, New York	Tanker	10,100	2,800	1	10,100
Sandard Oil Company of California, San Francisco, Cal.	Tanker	10,200	2,800	1	10,200
General Petroleum Company, San Francisco, Cal.	Tanker	10,200	2,800	1	10,200
	Fore River Plant, Quincy, Mass.				
United States Navy	Battle Cruiser	34,800	180,000	1	34,800
United States Navy	Scout Cruisers	7,100	90,000	2	14,200
United States Navy	Battleship	43,000	65,000	1	43,000
United States Navy	Submarines	1,106.2	4,000	3	3,318.6
United States Navy	Submarines	854	1,200	13	11,102
United States Navy	Submarines	860	1,200	6	5,160
Ore Steamship Corporation, New York	Ore Carrier	11,500	2,500	1	11,500
Standard Transportation Company, New York	Tankers	12,620	3,200	4	50,480
Atlantic, Gulf & West Indies Steamship Lines, New York	Tanker	12,620	3,200	1	12,620
Sinclair Navigation Company, New York	Tankers	10,600	2,600	2	21,200
United States Shipping Board	Tankers	9,100	.....	2	18,200
	Fore River Plant, Quincy, Mass.				
United States Navy	Destroyers	1,225	27,000	5	6,125
	Moore Plant, Elizabeth, N. J.				
United States Shipping Board	Cargo	5,100	1,450	2	10,200
Standard Oil Company of New York	Oil Barges	690	.....	3	2,070
	Harlem Plant, Wilmington, Del.				
United States Shipping Board	Cargo	7,400	2,500	3	22,200
United States Shipping Board	Cargo	5,100	1,450	2	10,200
United States Shipping Board	Tankers	7,500	2,600	3	22,500
Sinclair Navigation Company, New York	Tankers	10,600	2,600	2	21,200
Sinclair Navigation Company, New York	Tankers	6,900	2,600	2	13,800
British Interests	Tankers	8,500	.....	2	17,000
British Interests	Tankers	7,300	.....	2	14,600
	Sparrows Point Plant, Sparrows Point, Md.				
United States Shipping Board	Passenger	10,100	12,000	8	80,800
United States Shipping Board	Tankers	10,100	2,800	2	20,200
Standard Transportation Company, New York	Tankers	10,100	2,800	3	30,300
Vacuum Oil Company, New York	Tanker	10,200	2,800	1	10,200
Atlantic, Gulf & West Indies Steamship Lines, New York	Tankers	12,620	3,200	3	37,860
Ore Steamship Corporation, New York	Ore Carrier	20,000	.....	1	20,000
International Petroleum Company	Ore Carrier	20,000	.....	1	20,000
	A. C. Brozen & Sons, Tottenville, N. Y.				
United States Shipping Board	Harbor Tugs (length 100 ft.)	.....	.....	4	.....
	Carolina Ship Building Corporation, Wilmington, Del.				
United States Shipping Board	Cargo	9,600	2,800	12	115,200
	Chance Marine Construction Company, Annapolis, Md.				
United States Shipping Board	Tugs (length 100 ft.)	.....	.....	3	.....
	R. J. Chandler Shipbuilding Company, Los Angeles, Cal.				
San Diego & Coronado Ferry Company	Ferryboat	.....	.....	1	.....
Los Angeles Shipbuilding Company	Drydock	10,000	.....	..	10,000
	Chicago Shipbuilding Company, Chicago, Ill.				
United States Shipping Board	Freighters	3,500	.....	40	140,000

* Naval construction tonnage is given in terms of displacement.

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OWNER	TYPE	DEADWEIGHT TONNAGE	HORSE-POWER	NO. OF VESSELS	TOTAL DEAD-WEIGHT TONNAGE
Chickasaw Shipbuilding Company, Mobile, Ala.					
Builder	Freighters	6,869	.....	6	41,214
United States Steel Corporation, New York	Freighters	6,000	.....	10	60,000
.....	Freighters	9,600	.....	4	38,400
Clayton Ship & Boat Building Corporation, Clayton, N. Y.					
United States Navy	Deep-Hold Barges	.....	.....	15	.....
United States Navy	Tugs (length 88 ft.)	.....	.....	3	.....
Clooney Construction & Towing Company, Westlake, La.					
.....	Barges	588	.....	5	2,940
.....	Barges	60	.....	2	120
.....	Dredge Hull	.....	.....	1	.....
.....	Barges	500	.....	3	1,500
.....	River Barges	.....	.....	6	.....
Coastwise Shipbuilding Company, Baltimore, Md.					
United States Shipping Board	Schooner Barge	2,500	.....	3	7,500
Northern Transportation Company	Schooners	2,000	.....	4	8,000
Consolidated Shipbuilding Corporation, Morris Heights, N. Y.					
United States Shipping Board	Tugs (length 100 ft.)	.....	.....	5	.....
United States Government	Lightship	.....	.....	1	.....
.....	230-Foot Steam Yacht	.....	.....	1	.....
William Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa.					
United States Navy	Tankers	10,000	2,800	2	20,000
United States Shipping Board	Freighters	9,400	3,400	2	18,800
.....	Car Ferry	2,300	.....	1	2,300
.....	Passenger and Freight (350 ft.)	.....	.....	1	.....
United States Navy	Destroyers	1,215	28,000	17	20,655
United States Navy	Scout Cruisers	7,100	90,000	5	35,500
Crosby Navigaton Company, Bath, Maine					
.....	4-Masted Schooner (length 180 ft.)	.....	.....	1	.....
Cumberland Shipbuilding Company, Portland, Maine					
.....	4-Masted Schooner	1,800	.....	1	.....
Oscar Daniels Company, Tampa, Fla.					
Standard Oil Company of New Jersey	Tankers	11,900	2,800	2	23,800
United States Shipping Board	Freighters	9,500	2,800	7	66,500
Defoe Shipbuilding Company, Bay City, Mich.					
United States Navy	Mine Planters (length 100 ft.)	.....	350	8	.....
Delaware Shipbuilding and Repair Company, Camden, N. J.					
.....	Seagoing Barge	2,500	.....	1	2,500
Denton Shore Lumber Company, Tampa, Fla.					
.....	2-Masted Schooner Barges	500	.....	2	.....
Dierks-Blodgett Shipbuilding Company, Pascagoula, Miss.					
United States Shipping Board	Freighters	3,500	.....	3	10,500
United States Shipping Board	Combination Steamers	8,000	.....	4	32,000
Doullut & Williams Shipbuilding Company, New Orleans, La.					
United States Shipping Board	Cargo	9,600	2,800	8	76,800
Downey Shipbuilding Corporation, Arlington, Staten Island, N. Y.					
Southern Pacific Company, New York	Freighters	5,000	.....	3	15,000
Coastwise Transportation Company, Boston, Mass	Passenger and Freight	.....	.....	1	.....
The Dravo Contracting Company, Pittsburgh, Pa.					
United States Shipping Board	Barges	3,000	.....	2	6,000
United States Government	Barges	2,500	.....	12	30,000
United States Government	Tugs	300	.....	3	900
Dravo Contracting Company	Derrick Barges	.....	.....	2	.....
Keystone Sand & Supply Company	Barges	500	.....	4	2,000
Dubuque Boat & Boiler Works, Dubuque, Ia.					
.....	Steel Barges (length 300 ft.)	.....	.....	7	.....
United States Government	Barges	.....	.....	1	.....
.....	Ferryboat	.....	.....	1	.....
Dunn & Elliott Company, Thomaston, Maine					
.....	4-Masted Schooner (length 209 ft.)	.....	.....	1	.....
J. F. Duthie & Company, Seattle, Wash.					
Coastwise Steamship & Barge Company, Seattle, Wash.	Freighter	2,350	.....	1	2,350
United States Shipping Board	Cargo	8,800	2,800	3	26,400
East Coast Ship Company, Somerville, Mass.					
.....	Schooner	1,250	.....	1	.....
Elliot Bay Shipbuilding Company, Seattle, Wash.					
Weiss Packing Company, Seattle, Wash	Wooden Motorships	3,000	1,000	5	15,000
.....	Motorships	3,000	1,000	4	12,000
.....	Wooden Freighters	3,500	.....	5	17,500
Fabricated Ship Corporation, Milwaukee, Wis.					
Coast Artillery Corps, United States Army	Mine Planters	1,000	900	9	9,000
Transportation Service, War Department	River Steamers	600	700	4	2,400
Federal Shipbuilding Company, Kearney, N. J.					
United States Steel Corporation, New York	Freighters	9,700	2,500	3	29,100
United States Steel Corporation, New York	Freighters	9,650	2,500	10	96,500
Standard Oil Company of New Jersey	Tankers	15,100	3,500	5	75,500
Freeport Sulphur Company	Tankers	6,600	1,700	2	13,200
Ferguson Steel & Iron Company, Buffalo, N. Y.					
.....	Seagoing Tug	.....	.....	1	.....
.....	Tug (length 75 ft.)	.....	.....	1	.....
.....	Refrigerator Ships	.....	.....	2	.....
Foundation Company, New Orleans, La.					
Republic of France	Cargo	4,300	1,400	5	21,500
Frye, Flynn Company, Harrington, Maine					
.....	4-Masted Schooners (length 185 ft.)	.....	.....	2	.....
Gibbs Gas Engine Company, Jacksonville, Fla.					
United States Shipping Board	Harbor Tugs (length 100 ft.)	.....	.....	4	.....
Globe Shipbuilding Company, Superior, Wis.					
United States Shipping Board	Freighters	4,050	1,500	4	16,200
Grays Harbor Motorship Corporation, Aberdeen, Wash.					
Builder	Barkentines	2,500	.....	5	12,500
Builder	Barges	700	.....	2	1,400
Great Lakes Engineering Works, Detroit, Mich.					
United States Shipping Board	Cargo	4,050	1,500	7	28,350
.....	Tugs (length 88 ft.)	.....	350	2	.....
.....	Motorboats	.....	4,300	21	.....
Groton Iron Works, Groton, Conn.					
United States Shipping Board	Cargo	9,400	2,800	3	28,200
United States Shipping Board	Cargo	8,800	2,500	6	52,800
Groton Iron Works, Groton, Conn.					
United States Shipping Board	Wooden Freighters	3,500	.....	3	10,500
Gulf Shipbuilding Company, Millville, Fla.					
Builder	Motor Schooner	2,200	400	1	2,200

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OWNER	TYPE	DEADWEIGHT TONNAGE*	HORSE-POWER	NO. OF VESSELS	TOTAL DEAD-WEIGHT TONNAGE
	Hanlon Dry Dock & Shipbuilding Company, East Oakland, Cal.				
United States Shipping Board	Cargo	5,350	1,800	7	37,450
	Heldenfels Brothers, Rockport, Texas				
United States Shipping Board	Barge	4,000	.....	2	8,000
	Herreshoff Manufacturing Company, Inc., Bristol, R. I.				
.....	Steel Schooner Yacht (length 109 ft.)	.....	100	1	.....
.....	Steam Yacht (length 140 ft.)	.....	1,500	1	.....
.....	Motor Yacht (length 82 ft.)	.....	250	1	.....
.....	Motor Yacht (length 66 ft.)	.....	400	1	.....
.....	Motor Yacht (length 58 ft.)	.....	60	1	.....
	Hollywood Shipbuilding Company, Oakland, Cal.				
United States Shipping Board	Cargo	8,800	2,800	4	35,200
	Howard Ship Yards & Dock Company, Jeffersonville, Ind.				
Great Southern Refining Company	Oil Barges	.....	.....	3	.....
Engineering Corps, United States Army	Tunnel Tow Boats	.....	.....	3	.....
Engineering Corps, United States Army	Maneuver Boat	.....	.....	1	.....
	International Shipbuilding Company, Pascagoula, Miss.				
J. A. Bondi	Freighters	4,200	.....	8	33,600
.....	Barkentines	3,600	.....	2	7,200
	Jahncke Shipbuilding Corporation, New Orleans, La.				
.....	Standard Wooden Freighters	3,500	.....	12	42,000
.....	Drydock	10,000	.....	1	10,000
	Job Shipyard Corporation, Machias, Maine				
Builder	Schooners	1,350	.....	2	2,700
Builder	Schooner	2,500	.....	1	2,500
Builder	Barge (length 118 ft.)	.....	.....	1	.....
United States Shipping Board	Harbor Tugs	.....	.....	2	.....
	The Johnson Iron Works, Ltd., New Orleans, La.				
Cortez Oil Corporation	Barge (length 100 ft.)	.....	.....	1	.....
United States Shipping Board	Harbor Tugs (length 100 ft.)	.....	800	2	.....
	Kingston Shipbuilding Company, Kingston, N. Y.				
United States Shipping Board	Floating Drydock	16,000	.....	1	16,000
	Kyle & Purdy Incorporated, City Island, N. Y.				
United States Shipping Board	Tugs (length 150 ft.)	.....	.....	4	.....
East Coast Fisheries Company	Trawlers (length 150 ft.)	.....	.....	2	.....
M. Fleischmann	Yacht (length 145 ft.)	.....	.....	1	.....
	Lake and Ocean Shipbuilding Company, Cleveland, Ohio				
Hannevig, Inc., New York	Motorships	3,000	1,000	3	9,000
.....	Freighter	3,500	.....	1	3,500
	The Lake Torpedo Boat Company, Bridgeport, Conn.				
United States Navy	Submarines	.....	.....	8	.....
	George Lawley & Son Corporation, Neponset, Mass.				
United States Navy	Torpedo Testing Barge	.....	.....	1	.....
Edgar Palmer	3-Masted Auxiliary Schooner	.....	.....	1	.....
R. T. Crane, Jr.	Steel Motor Yacht (length 108 ft.)	.....	.....	1	.....
J. H. Walker	Wood Motor Yacht (length 115 ft.)	.....	.....	1	.....
	Leathem & Smith Towing & Wrecking Company, Sturgeon Bay, Wis.				
United States Shipping Board	Harbor Tugs (30 tons, gross)	.....	450	4	120
.....	Harbor Tugs (30 tons, gross)	.....	450	8	240
	Le Parmentier Shipbuilding Corporation, New York City				
Republic of France	Cargo	4,240	1,400	2	8,480
	Fred T. Ley Company, Mobile, Ala.				
United States Shipping Board	Concrete Tankers	7,500	2,800	2	15,000
United States Shipping Board	Concrete Freighters	7,500	2,800	2	15,000
	Liberty Shipbuilding Company, Wilmington, N. C.				
United States Shipping Board	Concrete Tankers	3,500	1,400	2	7,000
	Lone Star Shipbuilding Company, Beaumont, Texas				
French Interests	Freighters	4,200	.....	6	25,200
	Long Beach Shipbuilding Company, Long Beach, Cal.				
United States Shipping Board	Cargo	8,800	2,800	4	35,200
.....	Cargo	1,600	.....	1	1,600
.....	Cargo	1,700	.....	1	1,700
California & Mexico Steamship Company	Passenger	.....	.....	2	.....
Standard Oil Company, New York	Tanker	950	.....	1	950
	Los Angeles Shipbuilding & Dry Dock Company, San Pedro, Cal.				
United States Shipping Board	Freighters	8,800	3,500	12	105,600
United States Shipping Board	Freighters	11,300	3,500	5	56,500
	McAteer Ship Building Company, Seattle, Wash				
Quartermaster Department, United States Army	Supply	1,000	.....	1	1,000
	McDougall-Duluth Company, Duluth, Minn.				
United States Shipping Board	Cargo	4,150	1,500	7	29,050
Roberts Steamship Company	Cargo	3,600	1,250	5	18,000
Builders	Freighters	2,338	.....	4	9,352
Barnes Steamship Company	Freighter	2,338	.....	1	2,338
	MacDonald Engineering Company, Arkansas Pass, Texas				
France and Canada Oil Transport Company, New York	Concrete Tankers	2,000	640	2	4,000
	Manistee Shipbuilding Company, Manistee, Mich				
Northern Transportation Company, Wilmington, Del.	Barges	3,750	.....	2	7,500
.....	Schooner Barge	4,000	.....	1	4,000
	Manitowoc Shipbuilding Company, Manitowoc, Wis.				
United States Shipping Board	Freighters	4,050	1,500	6	24,300
Atlantic Fruit Company, New York	Freighters	1,900	.....	2	3,800
	John H. Mathis, Camden, N. J.				
United States Shipping Board	Harbor Tugs (length 100 ft.)	.....	.....	2	.....
	J. E. Matton, P. O. Waterford, N. Y.				
E. G. Murray Lighterage & Transport Company	Grain Barges	650	.....	6	3,900
.....	Grain Barge	650	.....	1	650
Lake Champlain Transportation Company	Grain Barges	650	.....	2	1,300
Champlain Boat Company	Grain Barges	650	.....	2	1,300
Builder	Grain Barges	650	.....	4	2,600
	P. J. Matton, Waterdiet, N. Y.				
.....	Canal Barges	650	.....	2	1,300
Capt. George King	Canal Barges	800	.....	2	1,600
Homer Bond	Canal Barge	800	.....	1	800
Theodore Miller	Canal Barge	750	.....	1	750
Frank Washrod	Reinforced Barges	.....	.....	2	.....
	Merchant Shipbuilding Corporation, New York Chester Yard, Chester, Pa.				
Shawmut Steamship Company, Boston, Mass.	Freighters	10,000	.....	2	20,000
Union Oil Company of California	Tankers	10,000	.....	2	20,000
Cochrane-Harper Company, Boston, Mass.	Tankers	10,000	.....	2	20,000
American-Hawaiian Company, New York	Motorships	11,000	.....	2	22,000
United States Shipping Board	Freighters	9,000	3,000	10	90,000
Union Oil Company of Delaware	Tankers	10,500	.....	2	21,000

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OWNER	TYPE	DEADWEIGHT TONNAGE*	HORSE-POWER	NO. OF VESSELS	TOTAL DEAD-WEIGHT TONNAGE
	Harriman Yard, Bristol, Pa.				
Atlantic, Gulf & West Indies Steamship Lines, New York.	Tankers	12,500	.....	6	75,000
United States Shipping Board	Freighters	8,800	3,000	18	158,400
	Merrill-Stevens Shipbuilding Corporation, Jacksonville, Fla.				
United States Shipping Board	Freighters	6,000	2,000	3	18,000
.....	Freighter	6,000	2,000	1	2,000
	Mobile Shipbuilding Company, Mobile, Ala.				
United States Shipping Board	Freighters	5,000	1,600	10	50,000
	Moore Shipbuilding Company, Oakland, Cal.				
United States Shipping Board	Refrigerator	9,400	2,800	1	9,400
United States Shipping Board	Freighters	9,400	2,800	7	65,800
United States Shipping Board	Tankers	10,000	2,800	7	70,000
Matson Navigation Company, San Francisco, Cal.	Freighters	14,000	6,000	2	28,000
Standard Oil Company of New Jersey	Tankers	7,000	.....	3	21,000
Standard Oil Company of California	Tanker	900	.....	1	900
Vacuum Oil Company, New York	Tanker	10,000	.....	1	10,000
	Narragansett Ship Building Company, Tiverton, R. I.				
.....	Drydock Pontoons	1,500	.....	8	12,000
United States Government	Drydock	20,000	.....	1	20,000
	Nashville Bridge Company, Nashville, Tenn.				
United States Shipping Board	Barge	1,800	.....	2	3,600
	National Ship Building Company, New York				
.....	Wooden Cargo Ship	5,000	1,450	4	20,000
.....	Oil Barge	.....	.....	1	.....
	National Shipbuilding Corporation, New Orleans, La.				
.....	Oil Barges	1,200	.....	7	8,400
.....	Fruit Barges	500	200	4	2,000
	Newburgh Shipyards, Newburgh, N. Y.				
United States Shipping Board	Freighters	8,800	.....	2	17,600
Union Sulphur Company, New York	Sulphur Carriers	7,000	.....	2	14,000
Aryamel Fruit Company, New Orleans	Freighters	2,500	.....	3	7,500
	Newcastle Shipbilding Company, Damariscotte, Maine				
.....	5-Masted Schooner	2,600	.....	1	2,600
.....	Schooners	1,000	.....	2	2,000
	Newport News Shipbuilding & Dry Dock Company, Newport News, Va.				
United States Navy	Battleship	32,500	65,000	1	32,500
United States Navy	Destroyers	1,225	28,000	4	4,900
Standard Oil Company of New Jersey	Tankers	20,500	3,800	2	41,000
Atlantic, Gulf & West Indies Steamship Lines, New York.	Tankers	7,000	.....	2	14,000
United States Shipping Board	Passenger and Cargo	13,500	12,000	2	27,000
United States Shipping Board	Tankers	11,375	2,800	5	56,875
	Newport Shipbuilding Company, New Bern, N. S.				
.....	River Steamers	700	600	6	4,200
	New York Shipbuilding Corporation, Camden, N. J.				
United States Shipping Board	Passenger and Cargo	13,500	12,000	9	121,500
United States Shipping Board	Passenger and Cargo	11,000	6,000	7	77,000
W. R. Grace & Company, New York	Tanker	9,340	.....	1	9,340
Standard Transportation Company, New York	Tanker	12,600	.....	3	37,800
United States Navy	Battle Cruisers	43,500	180,000	1	43,500
United States Navy	Battleships	32,500	60,000	2	65,000
United States Navy	Destroyers	1,200	28,000	22	26,400
	Northwest Engineering Works, Green Bay, Wis.				
.....	Tugs	176	709	2	352
.....	Tugs	450	1,000	5	2,250
United States Shipping Board	Tugs (length 150 ft.)	.....	800	5	.....
	Norway Pacific Construction & Dry Dock Company, Everett, Wash.				
United States Army	Transport	16,000	5,000	1	16,000
Coast Guard Service	Service Cutters	1,600	2,600	5	8,000
	Pacific-American Fisheries Company, South Bellingham, Wash.				
Builder	Wooden Freighter	3,500	1,500	3	10,500
	Pacific Coast Shipbuilding Company, San Francisco, Cal.				
United States Shipping Board	Cargo	9,400	3,200	7	65,800
.....	Freighters	6,000	.....	2	12,000
	Pacific Marine & Construction Company, San Diego, Cal.				
United States Shipping Board	Concrete Tankers	7,500	2,800	2	15,000
	Peninsula Shipbuilding Company, Muskegon, Mich.				
United States Shipping Board	Sailing Vessels	4,000	.....	2	8,000
	Peninsula Shipbuilding Company, Portland, Ore.				
.....	6-Masted Schooners	4,000	.....	2	8,000
	Pensacola Shipbuilding Company, Pensacola, Fla.				
United States Shipping Board	Cargo	9,000	3,000	6	54,000
	J. H. Price Shipbuilding Company, Seattle, Wash.				
Christoffer Hannevig, New York	Motorships	3,000	.....	2	6,000
	Providence Engineering Corporation, Providence, R. I.				
United States Shipping Board	Ocean Tugs (length 150 ft.)	.....	800	4	.....
	Pusey & Jones Company, Wilmington, Del.				
United States Shipping Board	Cargo	4,300	1,650	4	17,200
.....	Freighters	12,500	3,000	6	75,000
Anglo-Saxon Company, London	Tankers	8,500	.....	4	34,000
Shell Transport Company	Tankers	8,500	.....	4	34,000
French Interests	Tankers	8,500	.....	3	25,500
Eastern Steamship Company, Boston, Mass.	Freighter	2,750	.....	1	2,750
	Rolph Shipbuilding Company, Humboldt Bay, Cal.				
United States Shipping Board	Cargo	3,500	.....	2	7,000
	George D. Ryan & Son, Oshkosh, Wis.				
.....	Coal Barge	350	.....	1	.....
	Saginaw Shipbuilding Company, Saginaw, Mich.				
United States Shipping Board	Freighters	4,050	1,400	6	24,300
	San Francisco Shipbuilding Company, Oakland Bay, Cal.				
United States Shipping Board	Concrete Tankers	7,500	2,800	2	15,000
	Schaw-Batcher Company, San Francisco, Cal.				
Union Oil Company of California	Tankers	12,000	.....	2	24,000
	Seaboard Transportation & Shipping Company, Galveston, Texas				
Builder	Tank Barge (capacity 25,000 barrels)	.....	.....	1	.....
Builder	Tank Barge (capacity 18,000 barrels)	.....	.....	1	.....
	Seattle Construction & Dry Dock Company, Seattle, Wash.				
United States Shipping Board	Cargo	7,500	2,400	2	15,000
	Seattle North Pacific Shipbuilding Company, Seattle, Wash.				
United States Shipping Board	Cargo	9,400	2,800	1	9,400
	Skinner & Eddy Corporation, Seattle, Wash.				
Builder	Freighters	7,350	.....	4	29,400

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OWNER	TYPE	DEADWEIGHT TONNAGE*	HORSE-POWER	NO. OF VESSELS	TOTAL DEAD-WEIGHT TONNAGE
	Southwestern Shipbuilding Company, Los Angeles, Cal.				
United States Shipping Board	Cargo	8,800	2,800	8	70,400
Builder	Freighter	2,800	.....	1	2,800
	Standard Shipbuilding Company, Shooter's Island, S. I., N. Y.				
Cuyamel Fruit Company, New Orleans, La	Fruit and Passenger (length 235 ft.)	.....	.....	2	.....
Eagle Oil Transport Company, London	Tanker	8,400	.....	4	33,600
United States Shipping Board	Freighters	7,400	2,500	4	29,600
	G. M. Standifer Construction Corporation, Portland, Ore.				
Standarl Oil Company of New Jersey	Tankers	.....	.....	3	.....
Green Star Steamship Corporation, New York	Cargo	9,000	.....	5	45,000
United States Shipping Board	Cargo	9,400	2,800	2	18,800
	Staten Island Shipbuilding Company, Port Richmond, S. I., N. Y.				
Tidewater Oil Company	Tanker	2,000	750	1	2,000
Galena Navigation Company	Tanker	4,000	.....	1	4,000
American Sugar Refining Company of New Jersey	Molasses Tanker	6,300	.....	2	12,600
Standard Oil Company of New York	Oil Barges	.....	.....	6	.....
United States Navy	Tugs	.....	1,800	6	.....
	Stockton Yard, Inc., Stockton Springs, Maine				
Builder	4-Masted Schooner	2,000	.....	2	4,000
	Submarine Boat Corporation, Newark, N. J.				
International Products Company	Refrigerators	1,400	.....	2	2,800
Builder	Freighters	5,350	1,500	75	401,250
	Sun Shipbuilding Company, Chester, Pa.				
United States Shipping Board	Cargo	10,200	2,800	2	20,400
Gulf Refining Company, Pittsburgh, Pa	Tankers	10,600	.....	2	21,200
Sun Company, Philadelphia, Pa	Tanker	10,600	.....	1	10,600
Atlantic, Gulf & West Indies Steamship Lines, New York	Tankers	10,600	.....	2	42,400
Atlantic, Gulf & West Indies Steamship Lines, New York	Tankers	12,000	.....	4	48,000
Sinclair Navigation Company, New York	Tankers	10,600	.....	2	21,200
Standard Oil Company of New York	Tankers	10,600	.....	2	21,200
Pan-American Petroleum Transport Co., Los Angeles, Cal.	Tankers	10,600	.....	2	21,200
Rotterdam Lloyd Steamship Company	Freighter	10,600	.....	1	10,600
French Interests	Tanker	8,000	.....	1	8,000
Union Oil Company of California	Tankers	12,500	.....	2	25,000
	Tank-Ship Building Company, Newburgh, N. Y.				
United States Navy	Oil Barges	500	150	5	2,500
Southern Oil & Transportation Corporation	Oil Barges	1,800	.....	2	3,600
	Terry Shipbuilding Corporation, Port Wentworth, Savannah, Ga.				
United States Shipping Board	Tanker	7,500	2,800	5	37,500
	The Texas Steamship Corporation, Bath, Maine				
United States Shipping Board	Tankers	9,370	3,000	4	37,480
United States Shipping Board	Motor Tanker	4,400	.....	1	4,400
Texas Company	Tankers	10,000	.....	4	40,000
	Todd Shipyards Corporation, New York, N. Y.				
United States Shipping Board	Freighters	7,500	2,800	12	90,000
Sincalir Navigation Company	Oil Barge	1,450	850	1	1,450
Donald Steamship Company	Fruit Carrier	1,500	1,000	1	1,500
United States Navy	Destroyer	1,125	28,000	1	1,125
United States Navy	Scout Cruisers	7,100	90,000	3	21,300
	Toledo Shipbuilding Company, Toledo, Ohio				
United States Shipping Board	Cargo	4,050	1,500	4	16,200
	E. James Tull, Pocomoke City, Md.				
.....	3-Masted Schooner	470	.....	1	470
.....	Auxiliary Schooner	.....	80	1	.....
	Union Construction Company, Oakland, Cal.				
United States Shipping Board	Tanker	2,000	.....	1	2,000
United States Shipping Board	Cargo	9,550	2,800	8	76,400
	Union Shipbuilding Company, Baltimore, Md.				
Aluminum Company of America	Freighters	4,600	.....	2	9,200
Gulf Refining Company, Pittsburgh, Pa	Tankers	9,500	.....	2	19,000
Builder	Freighters	9,600	.....	2	19,200
	United States Shipbuilding Corporation, Portland, Maine				
.....	Wooden Freighters	2,700	.....	2	5,400
.....	Fabricated Ships	6,000	.....	2	12,000
.....	Auxiliary Schooner	1,500	.....	1	1,500
	United States Steel Corporation, Mobile, Ala.				
.....	Freighters	3,300	1,250	2	6,600
	Universal Shipbuilding Company, Sturgeon Bay, Wis.				
United States Shipping Board	Carvo	2,500	.....	3	7,500
United States Shipping Board	Motorships	3,000	.....	2	6,000
	Virginia Shipbuilding Corporation, Alexandria, Va.				
United States Shipping Board	Freighters	9,400	2,800	7	65,800
	Charles Ward Engineering Works, Charleston, W. Va.				
United States Government	Tunnel Towboats (length 200 ft.)	.....	.....	2	.....
	Weehawken Dry Dock Company, Weehawken, N. J.				
.....	Freighters	7,500	.....	14	105,000
.....	Concrete Freighters	3,500	.....	12	42,000
	Western Pipe & Steel Company, San Francisco, Cal.				
Union Oil Company of California	Tankers	8,000	.....	2	16,000
United States Shipping Board	Cargo	8,800	2,800	5	44,000

Shipbuilding for Private Account

NEW records of activity in shipbuilding for private enterprise are being made by the shipyards of the United States, says a statement just issued by the Atlantic Coast Shipbuilders' Association. Entirely exclusive of tonnage building for the Shipping Board, 263 steel vessels, aggregating 1,256,573 gross tons, are in hand for business interests.

If the present rate of progress is maintained, the 2,000,000 ton mark should be passed by June. Only a few months remain until the Government will have completed its construction program, and there is every evidence that the shipbuilding plants, freed of Government restriction, will be in a position to continue to meet whatever calls may be made upon them.

Huge Shipbuilding Program Under Way

The million and a quarter gross tons of steel steamers now under construction compare with a total of only 148,515 tons of all types of vessels building in the United States at the outbreak of war. The present construction figure is equal to the entire American output of shipping for 1914, 1915 and 1916, combined and 300,000 above the production for 1917. It is equal to the British output for

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STEEL VESSELS UNDER CONSTRUCTION IN AMERICAN YARDS FOR PRIVATE ACCOUNT

BUILDERS	OWNERS	TYPE	GROSS TONNAGE	NO	TOTAL TONNAGE
Alabama & New Orleans Transportation Company	Pan American Petroleum & Transportation Company	Tanker	1,371	2	2,742
American Bridge Company	Sinclair Navigation Company	Barge	500	4	2,000
" " "	Missouri Portland Cement Company	Barge††	300	3	900
American Shipbuilding Company	Builders	Freighter†	2,338	10	23,380
" " "		Freighter*	4,500	4	18,000
Baltimore Dry Dock and Shipbuilding Company	Builders	Tanker*	8,000	2	16,000
Bath Iron Works	Crowell & Thurlow	Freighter†	5,600	1	5,600
Bayles Shipbuilding Company	Nyack Shipbuilding Company	Tanker*	950	1	950
Bethlehem Shipbuilding Company:					
Fore River	Atlantic, Gulf & West Indies Company	Tanker†	8,900	1	8,900
" "	Ore Steamship Company	Ore Ship*	7,150	1	7,150
" "	Sinclair Navigation Company	Tapker†	6,600	2	13,200
" "	Standard Transport Company	Tanker*†	8,900	2	17,800
" "	Standard Transport Company	Tanker†	8,900	2	17,800
Harlan Plant	Sinclair Navigation Company	Tanker*†	6,600	2	13,200
" "	Standard Oil of New Jersey	Tanker*	13,500	2	27,000
Sparrows Point	Atlantic, Gulf & West Indies Company	Tanker†	7,500	1	7,500
" "	Atlantic, Gulf & West Indies Company	Tanker*	8,000	2	16,000
" "	Standard Transport Company	Tanker*	8,000	1	8,000
" "	Standard Transport Company	Tanker†	7,500	1	7,500
" "	Standard Transport Company	Tanker†	7,150	2	14,300
" "	Vacuum Oil Company	Tanker†	7,150	1	7,150
San Francisco	General Petroleum Company	Tanker†	7,500	1	7,500
" "	Pan-American Petroleum & Transportation Company	Tanker*†	7,500	3	22,500
" "	Standard Oil of California	Tanker*	7,500	2	15,000
" "	Standard Oil of New York	Tanker†	7,500	1	7,500
" "	Standard Transport Company	Tanker*	7,500	2	15,000
Brunswick Marine Corporation	R. L. Smith	Scow†‡	2,000	2	4,000
Clinton Shipbuilding and Repair Company	Baldwin Locomotive Works	Lighter††	1,600	1	1,600
" " " " "	Atlantic Refining Company	Oil Barge††	600	2	1,200
" " " " "	Union Petroleum Company	Oil Barge††	326	1	326
" " " " "	Union Petroleum Company	Oil Barge††	1,200	1	1,200
" " " " "	A. C. Churchman	Barge††	326	1	326
Cramp & Sons	W. R. Grace & Company	Motorship†	6,300	2	12,600
" "	Florida & East Coast Railway	Freighter††	2,406	1	2,406
Oscar Daniels Company	Standard Oil Company	Tanker†	7,800	2	15,600
Downey Shipbuilding Corporation	Southern Pacific Company	Freighter††	4,000	3	12,000
Federal Shipbuilding Company, Kearney, N. J.	Freeport Sulphur Company	Freighter*	4,400	2	8,800
" " " " "	Standard Oil Company	Tanker†	10,000	5	50,000
" " " " "	United States Steel Corporation	Freighter*	6,000	10	60,000
Chickasaw, Alabama	Builders	Freighter†	6,869	4	27,476
" "	United States Steel Corporation	Freighter*	6,000	10	60,000
George A. Fuller Company	Builders	Freighter†	9,600	4	38,400
Greenport Shipbuilding Company	Bay State Fisheries Company	Trawler*	292	2	584
International Shipbuilding Company	J. A. Bandi	Freighter†	4,200	8	25,600
Johnson Iron Works	Cortez Oil Corporation	Oil Barge††	200	1	200
Kyle & Purdy	East Coast Fisheries Company	Trawler†	355	2	710
Long Beach Shipbuilding Company	Standard Oil of California	Tanker*	950	1	950
" " " "	California-Mexico Steamship Company	Freighter††	1,150	1	1,150
" " " "	Domingo Nazabel Company	Freighter††	1,200	1	1,200
Manitowoc Shipbuilding Company	Atlantic Fruit Company	Fruit Str.†	2,000	2	4,000
McDougall-Doulutt Company	Barnes Steamship Company	Freighter†	2,338	1	2,338
" "	Builders	Freighter†	2,338	4	9,352
McEachern Shipbuilding Company	Brooks, Scanlon	Freighter*	4,500	1	4,500
Merchants Shipbuilding Corporation	Union Oil of Delaware	Tanker†	6,250	2	12,500
" "	Shawmut Steamship Company	Freighter†	7,300	2	14,600
Moore Shipbuilding Company	Matson Navigation Company	Freighter*†	9,500	2	19,500
" " "	Standard Oil of California	Tanker*	950	1	950
" " "	Standard Oil of New Jersey	Tanker*	7,000	3	21,000
" " "	Vacuum Oil Company	Tanker†	7,089	1	7,089
National Shipbuilding Company	Pan-American Petroleum & Transportation Company	Tanker†	1,371	2	2,742
" " "	Cuyamel Fruit Company	Fruit Str.†	250	3	750
Newburgh Shipbuilding Company	Cuyamel Fruit Company	Freighter†	3,000	2	6,000
" " "	Union Sulphur Company	Freighter†	4,700	2	9,400
New Jersey Dry Dock Company	East Coast Fisheries Company	Trawler†	355	2	710
Newport News Shipbuilding Company	Atlantic, Gulf & West Indies Company	Tanker*	7,000	2	14,000
" " "	Standard Oil of New Jersey	Tanker*	13,500	2	27,000
New York Shipbuilding Corporation	W. R. Grace & Company	Tankers†	7,753	1	7,753
" " "	W. R. Grace & Company	Tanker†	6,100	2	12,200
Pusey & Jones Company	Eastern Steamship Company	Freighter††	2,700	1	2,700
Schaw Batcher Shipbuilding Company	Union Oil of California	Tanker*†	8,000	2	16,000
Skinner & Eddy	Builders	Freighter*†	7,350	4	29,400
Southwestern Shipbuilding Company	Builders	Freighter*	5,300	1	5,300
Spedden Shipbuilding Company	Standard Oil Company	Oil Barge*	995	1	995
Standard Shipbuilding Corporation	Cuyamel Fruit Company	Fruit Str.†	1,500	2	3,000
G. M. Standiter Construction Company	Green Star Line	Freighter†	6,165	5	30,825
Staten Island Shipbuilding Company	Galena Signal Oil Company	Tanker†	2,500	1	2,500
" " " "	American Sugar Refining Company	Tanker*	4,200	1	4,200
" " " "	Standard Oil of New York	Barge††	420	6	2,520
" " " "	Standard Oil of New York	Barge††	450	1	450
Submarine Boat Corporation	Tidewater Oil Company	Tanker††	1,200	1	1,200
" " "	Builders	Freighter†	3,545	32	113,440
Sun Shipbuilding Company	International Products Company	Refrig.Str.†	1,400	2	2,800
" " "	Atlantic, Gulf & West Indies Company	Tanker*	8,000	1	8,000
" " "	Atlantic, Gulf & West Indies Company	Tanker†	6,700	3	20,100
" " "	Gulf Refining Company	Tanker†	6,700	1	6,700
" " "	Pan-American Petroleum & Transportation Company	Tanker†	6,700	2	13,400
" " "	Rotterdamsche Lloyd	Freighter†	7,700	1	7,700
" " "	Sinclair Navigation Company	Tanker†	6,700	2	13,400
" " "	Standard Oil of New Jersey	Tanker*	8,000	2	16,000
" " "	Sun Company	Tanker*†	6,689	1	6,689
" " "	Union Oil Company	Tanker†	9,000	2	18,000
Tank Shipbuilding Corporation	Societe Anonyne d'Orienent d'Industrie	Tanker††	8,000	1	8,000
" " "	Southern Oil & Transportation Company	Oil Barge†	835	2	1,670
Texas Company	Southern Oil & Transportation Company	Oil Barge††	775	2	1,550
" "	Builders	Tanker†	3,500	1	3,500
Todd Shipyards Corporation	Builders	Tanker††	6,700	3	20,100
" " "	Sinclair Navigation Company	Oil Barge†	1,800	1	1,800
Todd Dry Dock & Construction Company	Donald Steamship Company	Fruit Str.†	1,400	2	2,800
Union Construction Company	Stock	Freighter†	4,600	2	9,200
Union Shipbuilding Company	Standard Oil of California	Tanker*†	1,250	1	1,250
" " "	Aluminum Company of America	Freighter†	3,100	2	6,200
" " "	Builders	Freighter*†	7,150	2	14,300
Virginia Shipbuilding Corporation	Gulf Refining Company	Tanker†	6,100	2	12,200
	Builders	Freighter*†	6,200	7	43,400

Total Building: 263 Ships, aggregating 1,256,573 gross tons.

NOTE: * Classified by American Bureau of Shipping. † Classified by Lloyd's Register. †† Reported by United States Bureau of Navigation.

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1915 and 1916 together, about 100,000 tons above the 1917 total, only slightly under the British production for 1918, and equivalent to about 75 percent of that for last year in the United Kingdom. It exceeds the entire world's production of ships in 1915. And it is greater than the entire seagoing tonnage of this country at the beginning of the war. The most significant development, however, is that the volume of new orders continues to replace the gaps made by the completion, cancellation and suspension of Shipping Board contracts.

CARGO EXCEEDS TANKER TONNAGE

An interesting feature of the present return is that it shows that tanker tonnage, which a month ago, for the first time, exceeded the volume of freighter tonnage being built, has gone back to second place. There are now 620,000 gross tons of freighters building in comparison with 588,000 tons of tankers.

With the Shipping Board in possession of about 13,000,000 deadweight tons of vessels, the great bulk of which is composed of cargo carriers, the sale of which at low rates is being urged on Congress, the increase in private orders for freighters is a remarkable development. It may be taken to indicate that private enterprise, rather than take the chances of being able to supply its needs by waiting to select from a comparatively few types of ready-made ships, prefers to have modern ships built to its own designs with the assurance that they will be constructed for the particular service to which they are to be put.

RECORD INCREASE OF ORDERS

In the matter of increase of orders the past month has set a record, as the following monthly summary of tonnage under construction in comparison with the previous month shows:

	Gross Tons Building	Increase Over Previous Month
October	347,343	.....
November	550,714	203,371
December	805,147	254,433
January	977,488	172,341
February	1,256,573	279,085

The average increase per month since last October, when private construction began to reach sizable proportions, has been 227,000 tons.

How tanker tonnage, after steadily creeping up on the volume of carriers building, has lost ground is shown by the following comparison of the various types building at the different periods:

	Tankers	Freighters	Other Types
October	74,437	235,523	37,383
November	214,940	295,493	40,281
December	369,084	400,556	35,507
January	476,742	470,197	30,549
February	588,565	620,567	47,441

There is no evidence, however, that the demand for tankers is slackening, the increase of orders in hand for this type of vessel having been more than 100,000 tons during the past month. Construction for the Standard Oil companies still leads, but out of the total of 588,000 tons, more than half a million tons is for the account of other concerns

Of freighter tonnage, the largest amount under construction for one concern is comprised of twenty 6,000-ton vessels being built for the United States Steel Corporation.

BETHLEHEM AND FEDERAL YARDS LEAD

In the volume of tonnage building by the various shipbuilding companies the situation has developed into a close race between the Bethlehem Shipbuilding Corporation and the Federal Shipbuilding Company, the Bethlehem concern having taken the lead during the past month. Third and fourth places are held by the Sun Company and the Submarine Boat Corporation, respectively. The position of these companies in regard to number of vessels and tonnage for the past two months has been as follows:

	FEBRUARY		JANUARY	
	Number	Gross Tons	Number	Gross Tons
Bethlehem Shipbuilding Corporation	29	233,000	24	184,888
Federal Shipbuilding Company	31	206,276	35	208,276
Sun Company	16	117,989	14	98,717
Submarine Boat Corporation	34	116,240	12	38,250

Practically all of the Bethlehem and Sun companies' tonnage is composed of tankers, the Federal Company is building five tankers and twenty-six freighters, and the Submarine Boat Corporation has no tank steamers under way. All but two of the latter concerns' vessels are being constructed for builders' account and the growth of this class of work is a feature of the present return. The total of freighters taken over by the yards for their account is 74 vessels, aggregating 331,648 gross tons, 32 of which, totaling 113,440 tons, are for the Submarine Corporation. For the previous month, cargo carriers under way for builders' account aggregated 35 vessels of 142,158 tons. The volume of tankers taken over by builders is considerably smaller, because the Shipping Board has cancelled or suspended few of these accounts. The total now under construction is six vessels of 39,600 tons, compared with five of 32,000 tons for the previous month.

AMERICAN SHIPBUILDERS SHOW FAITH IN VESSEL MARKET

The faith of the American shipbuilder in his ability to find a market for his vessels is shown by this volume of freighter and tanker tonnage, totaling 80 vessels of 371,248 tons, in comparison with 40 of 174,158 tons under way for builders' account in January.

With no marked improvement in the foreign exchange situation, American yards are still practically entirely dependent upon domestic orders—only one new foreign contract was recorded during the past month, a tanker for the Societe d'Armement d'Industrie. How small a part this class of work is playing in American ship production is shown by the fact that of the 1,256,000 gross tons building in this country only about 15,000 tons is to foreign order.

Distribution of the work among the various shipyards is an encouraging feature of the returns. Another increase in this respect is recorded, fifty yards now being engaged in construction for private account, as compared with 43 in January, 38 in December, 31 in November and 27 in October.

In addition to the records of the American Bureau of Shipping and Lloyd's Register of Shipping, the chief classification societies, the returns include a number of vessels given by the United States Bureau of Navigation but not reported as being classified.

Details of all the steel construction under way for private account are given in the table on page 283 prepared by the Atlantic Coast Shipbuilders' Association.

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We Have the Ships! What Next?

BY CAPTAIN C. A. MCALLISTER, U. S. C. G. (RETIRED)*

The flood of new ships and the torrent of swollen freight rates have reached the crest and begun to subside. Already the high spots of normal conditions are discernible breaking through the receding waters of shipping turbulency. What does this mean? Is it the beginning or the end of our commercial venture upon the high seas? The observations of an "old salt" who knows the game, given in the following article, may help you to decide.

FOR several generations all true Americans have dreamed of the day when our flag would once again be a factor on the seas battling for commercial supremacy with our rivals. Almost as suddenly as the breaking of a dam, world conditions were thrown into a maelstrom involving nearly every nation on the globe. The cry heard above all others in this distressing period has been for ships and more ships. None among the nations responded so quickly and prolifically as our own United States. Vast of resources and bursting with patriotic energy America answered the call as never before could even have been dreamed possible.

So, among the flotsam and jetsam of this great disturbance, we find in our hands a mighty fleet of new ships ready to start in business for a merchant marine, after having fulfilled the shipping requirements of a great war and its immediate aftermath. I say "for a merchant marine" advisedly, as it is now brought home to us very acutely that something more than the ships is necessary to make a complete merchant marine. The phrase used extensively by a prominent cartoonist, "Now you've got it, what are you going to do with it?" applies with particular aptitude to our fleet of ships. It is "what are you going to do with it?" that concerns us all at the present moment.

What Are You Going to Do With It?

At the outset the writer wishes to record his unswerving belief that we are going to do the right thing with it. As a people we should now be thoroughly convinced as to the necessity of a merchant marine, and we will be untrue to the popular belief as to our national characteristic of shrewdness in money matters, if we let a more than three-billion-dollar investment in ships slip through our fingers without putting it to a profitable use. Hence, let all patriotic Americans who have ideas as to how we can bring forth the best results lend a hand at this critical period. From the writer's viewpoint the problem can be arranged under the following four general captions:

First.—Adopt the best methods of putting the ships into private control, as quickly as possible, without unduly sacrificing the Government's investments and without suddenly flooding the market for ship securities.

Second.—Americanize every function of the merchant marine: this to include operators, crews, insurance, classification, foreign agencies and banking facilities.

Third.—Popularize the merchant marine with the people by a systematic campaign of education, and the encouragement of small investors to place their money in shipping.

Fourth.—Economize in every function so that we will be enabled to meet the fierce competition of our rivals on the seas.

If those four general lines of endeavor are carried out to the best of our ability, the American people, with the intelligent backing of our Government in every legitimate manner, will demonstrate to the world that we can maintain a successful merchant marine.

Government Ownership Opposed

The first phase of the problem to be met is the disposition of the ships now the property of the Shipping Board. There is apparently but very little sentiment towards government ownership and operation, yet if the ships cannot be advantageously disposed of immediately, there is a strong sentiment that the Government should continue to own and operate. The main factors entering into the costs of operation are capital charges, depreciation, profit in the form of dividends, insurance, repairs, supplies and crew. The disposal of the ships now at about half their cost will, so long as these particular ships last, reduce the cost of operation in the matter of capital charge, depreciation and insurance to such an extent as to enable private operators to meet the competition of foreign ships not thus favored, and to that extent this plan is worthy of serious consideration. On the other hand, this method does not solve the problem of continuity of operation of the merchant marine.

Should the Government retain ownership and entrust operation to private parties, success could be obtained by the ownership disregarding capital cost, depreciation and profit as is done in all other governmental investments. That, however, is paternalism pure and simple. It would therefore seem logical to adopt a middle of the road policy, that is, to sell gradually to private operators having the capital and business at hand, and to permit new concerns to operate government-owned ships on a profit-sharing basis. Of course, in such an arrangement as this the greatest care would have to be exercised to prevent government-owned ships from competing with those privately owned.

Small Ships Should Be Sold At Once

As our enormous fleet was constructed primarily for war purposes and to best fulfill the immediate needs of great production, it is not naturally well balanced for commercial purposes. There is an excess of ships of the smaller type—those under 6,000 tons deadweight. A number of these can be used economically in our coasting trade and for feeders in certain branches of our foreign trade. The surplus of this type should therefore be sold abroad as rapidly as possible, as nothing deteriorates so quickly as an unused ship.

The disposition of the ships is after all a matter of discussion among ourselves. Under the second caption there is a more serious problem with which to contend.

Americanizing the Merchant Marine

With over half of the crews now operating our ships composed of aliens, many of them of the lowest order of intelligence, with hundreds of alien officers under temporary licenses, with two-thirds of our marine insurance placed with foreign companies and with half of the new

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ships building for private ownership in this country having their plans approved, materials tested and construction surveyed by foreign agencies, is it not high time that we took action, and at once, by Americanizing our merchant marine? How can we succeed in our efforts on the seas when we lean so heavily on the facilities of those with whom we are to compete? It is hard enough for any newcomer in a contest to succeed, even when all conditions are favorable. What then can be expected of the novice who either ignorantly or stupidly borrows facilities from several of his rivals?

There are many weak-kneed among us, who say, "It can't be done! Americans will not go to sea! We are not a sea-faring nation, etc., etc."

I claim to the contrary and, as best evidence that it can be done, have but to point to our Grand Old Navy. Not so many years ago but that most of us can remember it, the same despairing cry was raised about the enlisted men in the Navy. Then, with an authorized strength of 25,000 or so, less than one-third were citizens. Today, with over 100,000 men, the percentage of citizens is but a fraction below 100 percent. What has been done by the Navy can be done for the merchant marine.

True it is that the great masses of our population are remote from the seas, the majority probably never having seen salt water. Yet when you look into the ancestry of many of the farmers' sons in Minnesota, Kansas or other Western States, you will not have to go back many generations to find forebears who were New England fishermen, Scandinavian, English or other European followers of the sea. The call of the deep is latent in their predilections, and it has been demonstrated on innumerable occasions that men of such origin make the most efficient sea-farers in both the Navy and merchant marine.

Build Up a Naval Reserve in the Merchant Marine

The Shipping Board has conducted its own recruiting and training system and so far as it has gone has helped to a great extent. It is evident that additional means will have to be adopted, as the percentage of citizens among the Shipping Board crews is still less than half of all those employed. While the writer would be the last to advocate military training and discipline on strictly merchant ships, there is little doubt in his mind but that a system can be devised whereby many of the officers and men on merchant vessels can be enrolled in a naval reserve, and receive sufficient retainers from the money appropriated for the national defence to make up the difference between American wage schedules and the wages paid to corresponding grades on foreign ships. In times of war the Navy would benefit by having a large number of officers and men available for military duty, whose experience in ship handling had been as good or better than that obtainable on naval vessels in times of peace. Arrangements could be made whereby a certain small period of each man's enlistment could be spent on naval vessels for drill in strictly military duties.

The Navy recruiting system should be brought to aid this Americanization of the merchant marine. This system, so ably worked out, has accomplished wonders for the naval personnel, covering as it does all parts of the country. The higher pay, freedom from military discipline for the greater part of their enlistment, and above all the natural preference of young Americans to accomplish something constructive in times of peace, should make enlistments for the naval reserve comparatively easy. With the combined efforts of the Shipping Board training service and the naval recruiting service, it will not be long before our ships will be manned by all American crews. Whatever steps are necessary to accomplish this are well worth while, and nothing should be left untried to bring about this most desirable result.

Whether sailors unionize or not is a matter of small moment so long as they are American citizens. The aliens among the licensed merchant ship officers will soon after the declaration of peace have to become citizens or give up their American licenses.

American Insurance and Classification

The Americanization of insurance and classification facilities is being given the careful scrutiny of a very intelligent committee of Congress, and there seems to be little doubt of the passage in the near future of remedial laws covering both these collateral functions of a merchant marine. We must have both of these facilities under our control and management, and not depend upon foreigners to any degree. Aside from the advantages given to our competitors by the practical control of these vital necessities, it is a drain on the finances of the country, as there is absolutely no reciprocity in either of these transactions.

Popularizing the Merchant Marine

Under the third caption of popularizing the merchant marine, we open up a hitherto untrodden field of effort in this country. What can be accomplished along these lines is best illustrated by what happened in Germany. Many of us can remember when the German commercial fleet occupied about the same relative position as ours did in the years immediately preceding the world war. Realizing that their hopes of national expansion rested upon the building up of a merchant marine, they embarked upon an extensive campaign of educating the people both as to the necessity for ships, and in the art of building them. Graduates of their technical schools swarmed to the Clyde and soon imbibed knowledge and experience from the Scotch shipbuilders, who had for generations been studying the subject. Text books on the value of shipping were introduced in their schools and colleges and made parts of their curricula. Aided in every manner possible by all branches of the government, their efforts rapidly bore fruit, so that by the time they had arrived at the state of mind to commit hari kari, they had a merchant marine in size and importance second in the world. In creating this great fleet they had also annexed the reputation of having built the fastest transatlantic liner, as well as having constructed the largest ship the world has yet seen, now by the fortunes of a most righteous participation in the great war about to become the bell-wether of our Yankee fleet of merchantmen.

With no fear of such a disastrous ending to our maritime efforts, we might well emulate some of the methods which created that fleet. The chairman of the Shipping Board very wisely said in a recent address that for us to succeed, the people must be taught to think in terms of ships. No better plan could be adopted than for Congress to require through the Bureau of Education the dissemination of standard books on the subject to the various educational institutions throughout the country, with a request that a knowledge of the fundamentals of shipping be imparted to every student. The States should require the institution of a brief course in shipping essentials in every college, academy and high school within their jurisdictions. Organizations like the Marine League and the American Merchant Marine Association should vastly increase their membership, and send competent lecturers throughout the land to preach the advantages of a merchant marine to all the people.

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American citizens now have vast sums of money to invest in legitimate enterprises. Someone more versed in financial matters than the writer should devise means whereby the small investors may put their funds in shipping enterprises with a modicum of safety. Railroads, in a growing country, have proved to be attractive investments, but now that they are no longer attractive as expanding corporations, much of the money could well be placed in ships. Mortgage laws should be enacted which will protect the investors, and overcapitalization should be prevented by federal supervision of incorporation.

Under the fourth caption of economizing in all mercantile marine functions arises the most complex of the problems before us, as upon this phase depends to a great extent the survival of our fleet in the competition to come.

Economical Operation of Ships

An illiterate general when asked his opinion as to the acme of military strategy is alleged to have replied: "Get there fustest with the mostest men." This might well be paraphrased in defining the acme of maritime operations, as "Carrying the mostest cargo for the leastest money."

In the mad haste of the war all efforts at economy have been thrown to the winds. "Getting there fustest" has been the motto and the "leastest money" has cut but very little figure in our shipping activities. Now, however, we have got to reckon with costs in every manner possible. Wage costs follow natural conditions of supply and demand more nearly than any other element. Decreasing demand and increasing supply will soon bring that element to the normal. If we can help out our crew costs with the naval reserve aid, as hereinbefore mentioned, we need not greatly fear competition from that source. The overhead items of capital cost and depreciation will be less discriminating than ever before, on account of the gradual drawing together of the building costs at home and abroad. This drawing together is accelerated by our lower cost of steel. While we can continue to sell ship material to England and Japan, as we are now doing and have done for some time, that will always be one factor in our favor. Our shipyard labor may never be as low as that of our rivals, but there probably will never again be as wide a variance as there was in pre-war years.

Fuel cost for ship propulsion is the one factor where we should gain over our rivals, and our possession of two-thirds of the world's oil supply is the great natural advantage we have in the race. If we take full advantage of that, we can almost overcome our disadvantages. Fortunately we have a larger proportion of oil-burning vessels in our merchant fleet than any other nation.

Our Advantage in Oil Fuel

The increased cargo space, the decreased number of crew, and the less cost of oil fuel as compared with the corresponding items on vessels using coal as fuel, are too well known to dwell on at length in this discussion. We should push this advantage to the utmost, and if we cannot succeed by other means, the public oil and shale lands should be set aside for the exclusive use of our merchant marine. Some would go even further and carry out to a greater extent the system already adopted by the Shipping Board of establishing fuel stations in all parts of the world, accessible to all American trade routes by having the Government produce the oil, transport it to these outlying stations in tankers owned by the Government, and sell it to all American owned merchant vessels at the bare cost of production and delivery. It is claimed that we would thus be utilizing one of our great national resources for the benefit of the country at large, as all shades and sects of our population are directly or indirectly benefited by our possession of an efficient merchant marine.

To show the possibilities of a scheme such as this, I have but to quote the cost of fuel oil in one of our island possessions. Less than a year ago oil was sold to our merchant ships at a cost of $16 (3/6/8) per ton; now, since the establishment of a Shipping Board oil station, it is sold for just about half that amount. In the language of the official who showed me those figures, "Why argue about a few dollars' difference in pay to sailors as a deterrent to our merchant marine?"

In conclusion the writer desires to state that he is now, and always has been, a firm believer that we would eventually have a large and successful merchant marine. Now is the time, if ever. Some of my contentions may be overly optimistic, but if all true Americans will work together along the lines indicated herein, or along any other good lines having the same object in view, our success is assured.

What the Steamship Owners Recommend

BY H. H. RAYMOND, PRESIDENT AMERICAN STEAMSHIP OWNERS' ASSOCIATION

THE American Steamship Owners' Association, whose membership includes practically all of the corporations, firms or individuals that own and manage ocean-going steamships under the American flag in coastwise, West Indian or overseas commerce, from New England to the Gulf on the Atlanitc side, and also the principal companies whose home ports are on the Pacific Ocean and whose members own upwards of 2,500,000 gross tons of their own steam shipping, and in addition operate about 4,000,000 tons of Government-owned vessels of the Shipping Board fleet, has unanimously adopted the following resolutions, with a view to assisting Congress in the shaping of a definite, constructive National merchant marine policy:

Steamship Owners Resolutions Adopted November 10, 1919

Resolved, That in the opinion of the American Steamship Owners' Association, it is essential to the permanent success of an American merchant marine that the vessels comprising it should be owned and operated by American individuals, firms, corporations and associations.

To this end the association recommends:

(1) That steamers of less than 6,000 tons total deadweight capacity be promptly sold, with privilege of transfer of flag, at such prices as may be obtainable. That the Shipping Board be directed to sell as speedily as possible, and in any event within two years, all the remaining merchant vessels constructed or owned by the United States, including the ex-German tonnage, at world market prices (having regard to sales made by other governments since the armistice) to American citizens, firms or corporations, on terms of 25 percent cash and deferred payments of the balance of the purchase price over periods of ten to fifteen years, and deferred payments to bear interest at a rate not exceeding 5 percent and to be secured by a first mortgage.

(2) That after the sale of a portion of the fleet of vessels of over 6,000 tons total deadweight capacity each, the unsold remainder should, as far as practicable, be allocated by the Shipping Board to those who have purchased, on a basis of

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payment of a commission to the operating firms or corporations and payment by the operators of the proportion of the consolidated net earnings of the ships owned by such operators and the Government-owned tonnage which the operated tonnage bears to the total tonnage operated by such firms or corporations.

(3) That all individuals, firms or corporations who shall purchase and operate ships in the foreign trade, in pursuance of the foregoing plan, should be exempt in respect to the earnings of such ships from all Federal excess profits taxes for a period of ten to fifteen years. Provided that such individuals, firms or corporations be permitted to charge off 10 percent of the net earnings of such ships on account of depreciation, and deduct such amount in their tax returns as operating expenses, and provided further that an amount of earnings equivalent to the excess profits taxes that would otherwise be payable shall be invested by such individuals, firms or corporations in the building of new tonnage in American shipyards or in the purchase of tonnage built in American shipyards.

(4) That the Government should enact special legislation to assist existing passenger lines in the construction and operation of new passenger tonnage of the highest class and latest design and type, and to inaugurate and develop additional passenger and freight lines on routes on which it is desirable in the national interest that direct passenger and freight service should be established.

At another meeting of the Association on January 27 the resolutions of November 10 were unanimously reaffirmed, and in addition certain amplifying resolutions were adopted, as follows:

Resolved, That we particularly reaffirm the recommendation that government-owned ships of over 6,000 deadweight tons be sold only to American individuals, firms and corporations to be retained beneath the American flag.

American sea wages have always been higher than the sea wages of other and competing countries. This fact throughout our existence as a maritime nation has made it necessary for American shipowners to conduct their business with the utmost enterprise and economy, to adopt all possible labor-saving improvements, and, generally speaking, to operate larger ships than their rivals in ocean commerce. Our earlier maritime experience emphasizes the truth which all maritime men of today understand, that it is the relatively large sailing ships which can be made most effective and most profitable by American shipowners. A steamship of 8,800 or 9,600 deadweight tons requires no more deck officers or engineers than a steamship of 5,000 deadweight tons, and only a few more in number of firemen and seamen. That is to say, in the larger ships, carrying a larger cargo, each officer and man renders proportionately a greater carrying service than in the smaller ship—an economic fact of the utmost significance to the Nation that pays the higher per capita wages.

Moreover, American trade is characteristically a trade of relatively large cargoes, and many, in fact most of these cargoes, are carried long distances. On this account, again, the most advantageous ship for our purpose is the larger one. Those steamers of upwards 6,000 deadweight tons are the best hope of the American marchant marine of the future, and we recommend most earnestly that they be sold only to American citizens or corporations for the purpose of serving American commerce.

Another point on which we wish to lay emphasis is embodied in our second Resolution:

Resolved, That government-owned ships of less than 6,000 deadweight tons be sold preferably to American citizens, so far as there may be need of such ships in carrying American commerce, and that such of these ships be sold to foreign citizens or subjects with the privilege of a change of registry as the Shipping Board, after inquiry of all steamship owners and operators, shall decide are not required for the development of American trade routes or for the promotion of an efficient merchant marine. American purchasers should also have the right of resale to foreign subjects with the privilege of transfer of registry.

While the relatively large ship is the most valuable ship for the uses of our country, these smaller vessels of less than 6,000 deadweight tons in certain trades, as to the West Indies, for example, or on new routes which would have to be developed, are not without their desirability. Therefore, we believe that American citizens should be given the first choice in the purchase of these vessels, that they may be assured of all they desire for the development of new rontes or for use as feeders to the larger American ships, and that only those that do not seem to be required for our commerce be sold to foreigners for service under foreign flags. If the Government is to be authorized to sell the surplus of our lighter tonnage to foreigners, it is obvious that it would be just to authorize Americans who have purchased these ships to sell them also to foreigners when they have served their purpose and larger and newer vessels seem to be required. American owners of the smaller craft, therefore, should have equal opportunity with their government to dispose abroad of those that are not required for home use at any time.

Another point on which we would make an earnest recommendation is this:

Resolved, That it is the sense of the association that having regard to a proper equalization of capital charges with those of our principal foreign competitors, in point of depreciation, interest and insurance, all single-screw steel-built steamers of the government-owned fleet, of 12,900 deadweight tons and under, should be sold, as above recommended, at a price not exceeding $100 (20/16/8) a deadweight ton, depending upon the type, class and condition, with a proper allowance for depreciation for age, and with exemption for from 10 to 15 years from Federal excess profits taxation if employed in the foreign trade.

We specify ships of 12,900 deadweight tons and under in this resolution because all of the distinctively cargo-carrying steamships of the Government-owned fleet are of below 12,900 deadweight tons—the only larger vessels being the troop ships that are being constructed as passenger and cargo liners and are upwards of 13,000 tons and of high speed. These liners, of course, are worth a higher price than the slower single-screw cargo vessels.

It is our sincere conclusion, after a long and careful discussion of the matter, that $100 (20/16/8) a ton represents a price for the Government-owned cargo ships that cannot be exceeded if American shipowners who purchase them are to have anything like a fair and even chance in competition with the shipowners of other nations. It must be remembered that steel cargo steamers similar in type, and most of them, probably, of greater actual value than the ships of the Government-owned war-emergency fleet, could have been and were constructed in this country before the war for as low as $60 (12/10/0) to $65 (13/10/10) a deadweight ton. There were relatively few of these steel general cargo steamers in our merchant marine before the war, but there were thousands of such ships in the merchant fleets of Great Britain, Germany, Norway, France, Italy and Japan. In fact, some of these foreign-built cargo steamers were produced in the years before the war at as low a price as $30 (6/5/0), or even $35 (7/5/10) a deadweight ton. Great Britain, after all her war losses, still possesses upwards of 20,000,000 deadweight tons of ships that were in service before the war, and the average cost of these vessels, most of which are still good and serviceable, must have been well below $60 (12/10/0) a ton—liners, of course, not included. The high profits of the war period have probably enabled most British shipowners to mark their existing tonnage down to a nearly nominal valuation.

It is with this relatively low-cost shipping of the world's pre-war fleets that the high-cost steel steamers of the Shipping Board must go into close, sharp competition.

(*Concluded on page 292.*)

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Suggestions from the Shipbuilders

Views Expressed by Shipbuilders and Naval Architects Regarding the Future of the American Merchant Marine

IT is evident that the country has more ships intended for deep-sea service than it has organizations to operate and crews to man them. There are without doubt many ships that are unfitted for long trade routes, and possibly a surplus of good vessels for the shorter routes. If there are vessels which, on account of size, type, or arrangement, are not fitted for a particular trade or service, they should be sold, regardless of size, and if there are ships of poor design or structurally weak, they should be scrapped. Incompetent operators and crews should also be scrapped, for it is just as important that ships should be operated by capable managers and navigated by competent crews as it is to have the vessels well designed and structurally sound.

We have today many efficient individuals and organizations operating American vessels, but unfortunately there are not enough of them. It is hardly fair to expect that this country could, within a period of two or three years, build up organizations to operate the hundreds of ships we have built for ocean trade, that would equal those of other nations that have been operating deep-sea vessels for scores of years. In my opinion, if this country is to build up a solid, efficient and lasting merchant marine, it must be done through private initiative and enterprise, with the help, and not interference, of the Government.

M. E. Farr, President, American Shipbuilding Company.

IT is well known that the commerce of the world is largely carried by the ships flying the British flag; therefore, it is inevitable that if the United States is to take its proper place among the world carriers, a certain portion of the trade now carried by Great Britain must be taken over by the merchant marine of this country.

The treaty now in force between this country and Great Britain pertains entirely to direct commerce between the United States and Great Britain and its dependencies in Europe. Great Britain, at the time of making the treaty, absolutely refused to extend the treaty to its colonies, desiring to reserve that trade entirely for English ships.

At the present time it is understood that about 60 percent of the merchant marine of Great Britain is engaged in carrying foodstuffs from its colonies and other countries to Great Britain itself. It would therefore seem that the remedy for American shipping lies in getting into the world trade at once and in placing a heavy tax upon foreign vessels engaged in the indirect trade with this country; i. e., if a vessel, carrying the British flag, engages in trade between countries of South America, or its own colonies, and the United States, this vessel would be in the indirect trade and subject to the tonnage tax in addition to the duties already provided for in our own tariff laws.

Another aid that may be given to American ships is the granting of some form of rebate to the present duties to all importers and exporters bringing their goods to, or taking them away from this country in vessels flying the American flag. It may be that this form of legislation would make necessary the revision or total abrogation of treaties now in force between the United States and foreign countries; if so, it seems to me high time for the United States to notify such countries that it desires to terminate treaties antagonistic to the best interest of the Nation's merchant marine. If we have been careless in the past in guarding our sea rights, we should at once set about improving our position.

Another thing which militates against the best interest of the shipping trade is the very onerous exactions of the Seamen's Act, which causes the running expenses of our vessels to be increased out of proportion to those of foreign countries. Action should be taken in Congress modifying the present Seamen's Act to make it more nearly conform to the laws of Great Britain.

Another feature would be to retain in this country the cargo vessels built by the United States Shipping Board—at least all the vessels over 6,000 tons—and the sale of such ships guarded so that they could not be resold to steamship companies flying a foreign flag. These vessels should be used either by American steamship lines, or by the Shipping Board, in instituting new lines to ports where no American lines exist.

W. A. Dobson, Naval Architect, William Cramp & Sons Ship & Engine Building Company.

THE main questions, before the country to-day are: (1) what to do with the present ships, (2) what is to be our future policy, and (3) what must be done to retain our fleet and make it an operative possibility in face of competition? The question of the actual Government operation of ships is one that can be dismissed in a few words—*it won't work*. Anyone who is at all familiar with the business knows that this is true, despite any paper arguments that may be advanced to the contrary. But the Government may own or retain a partial interest in vessels, leaving the same to be operated by commercial firms at such terms as will be reasonably profitable to both parties. One fact should not be lost sight of in this connection. Even if it might appear that small, if any, profit accrued to the Government in the actual deal so far as the ships themselves are concerned, the indirect profit to the country as a whole from increased trade, stimulus to new trades, developments of new trade routes, etc., would represent an incalculable value—to the farmer, manufacturer, laborer, and, in fact, to the whole populace.

To attain this end, the second condition, i. e., future policy, must also be considered. It is useless to adopt half-hearted means to accomplish anything, and some definite and well-established policy to "see the thing through" is essential. No business has ever attained success unless those concerned have been continually looking into the future and anticipating, as far as possible, or creating, if necessary, future developments. The same is particularly true in connection with shipping. A sane or conservative programme, extending over a period of years, would not involve the country in any very serious financial obligations—almost microscopic when compared with some other expenditures such as pensions, etc.—and would do much, not only in making us more or less independent of the foreigner, but also in insuring the ultimate success of the merchant marine.

The third condition, i. e., making the fleet an operative

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possibility, is one where perhaps the Government is more especially a factor. It is a truth, and, I regret to say, a sad one, that practically every bit of legislation by Congress in relation to the merchant marine in the past decade or more has rendered the operation of ships less and less profitable or even impossible—at any rate it could not be called "constructive legislation" in the wildest flights of imagination. The removal of certain of these handicaps is of primary importance; and it argues poorly for the far-sighterness of certain legislators if, with the idea of gaining a great advantage for certain classes of labor, at the same time they so arrange things that this very labor that they wish to assist is driven out of a job.

The last, and probably the most vital, point where the Government can assist is in the establishment of trade centers and organizations in foreign countries. Ships are of no use unless you can have cargoes for them, and one of our present and greatest handicaps in foreign trade is the lack of proper agencies to get the goods for our ships. Other maritime countries have realized this, and the sooner we do, the better. Foreign cargoes are not apt to be hanging around, like fruit upon the trees, waiting to be plucked by any chance passerby; and it is only after proper and extensive connections have been established that there can be any hope of a successful mercantile marine.

In conclusion, contrary to the results of many other war activities which have to be written off as a dead loss, we have in our ships a real peace-time asset; and it only needs a little imagination and constructive legislation to make this a real benefit to the country as a whole.

H. C. Sadler, Professor of Naval Architecture, University of Michigan.

IT is my firm belief that the ships should be sold to American owners at the present market value of similar ships, with the understanding that the owners will pay 20 percent of the cost of the ship on taking possession of same and the Government will accept a mortgage on the ship for the balance at 3 percent interest, and with the further stipulation that additional payment of 10 percent of the cost price of the ship should be paid each year.

The ship should carry a certain number of officers and crew in the Naval Reserve unit, and preference should be given American-owned ships in connection with the facilities provided by the United States Government even at the expense of abolishing present trade treaties.

E. H. Ewartz, General Manager, Moore Plant, Bethlehem Shipbuilding Corporation, Ltd.

PROPER consideration of the following items I believe to be vital to the successful maintenance of the merchant marine of the United States. Briefly, these are three things:

(1).—A proper revision of the navigation laws, including a thorough revision of the laws for the measurements and inspection of merchant vessels by the United States Steamboat Inspection Service.

(2).—A system of properly financing individual ship operating companies of small caliber that will permit of the establishment of a large number of small operating companies which operate two, three or more ships, with the holdings in these vessels widely distributed in small lots.

(3).—A preferential treatment as far as tonnage dues for United States vessels through the Panama Canal.

H. A. Everett, Naval Architect, Union Shipbuilding Company.

MY suggestion would be that Congress should lay out a shipping program covering five years, during which time the people could be educated to the importance of the shipping proposition and realize how important it is to the nation. For the first two years the ships would be sold at $200 (41/13/4) a ton, and any American who wanted them could go in and buy them at that price. At the end of that period there would be a drop in the price. I would not suggest any definite figure. The price would depend upon conditions, but it ought to be sufficient to maintain the general American market, say around $175 (39/9/2) a ton. This price could be held for one or two years, when there could be a further drop in price, and at the end of the five years the remaining ships could be sold for what they would bring and the Government get out of the shipping business. During the five-year period the unsold ships could be allocated to ports as they are allocated now, on a profit-sharing basis.

This would give time for the establishment of new trade lines; it would give time for the education of the people to the importance of the shipping industry; it would give time for the average business man to learn the personal and business advantage of investment in ships; it would give time for the shipyards to do away with war methods and get down to an efficiency basis on which ships could be built in competition with the Clyde while still maintaining the high wages of American labor.

I am opposed to the plan of throwing our Government ships on the market at anything like the price of $140 (29/3/4) a ton. I want to see the Government's investments in the ships protected. I would like to see every port on the Atlantic and on the Pacific share in the fullest degree in the development of an American merchant marine, and get all the benefit that can come to them from foreign commerce. I am anxious to see the people of this country become a shipowning people; I would not like to see our great fleet pass to a few hands, no matter how strong and efficient they might be, and I would not like to see two or three ports and a few people reap the benefits that can come to the whole seaboard and to many thousands of Americans from the revival of the American merchant marine.

Holden A. Evans, President, Baltimore Dry Docks & Shipbuilding Company.

IN formulating our policy it should ever be kept in mind that the American merchant marine must be established in the face of strenuous opposition from foreign countries, whose citizens, from years of experience in operating vessels in world-wide markets, are already established in a commanding position that makes them strong opponents and competitors. It appears, therefore, to be absolutely essential for the next few years that some kind of preferential treatment be extended to American ships, built in American shipyards and operated in the overseas trade by American citizens. It must be a policy of wisdom and encouragement in order firmly to establish our merchant marine as one of the country's greatest assets.

Selfish and short-sighted American interests are demanding that these vessels—built with money contributed by the citizens of this country—be sold at what is little better than sacrifice prices, and this propaganda is being fostered and encouraged by lobbyists representing powerful foreign shipowning interests. So insistent and insidious is this propaganda that the country is facing a chaotic state of mind in which the necessity of establishing a national policy is lost sight of and the immediate

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sacrifice sale of ships, regardless of future policy, appears to be the paramount interest.

The national policy should also be formulated so that vessels now operated by the Shipping Board may be sold upon easy terms to private American citizens or American shipowning or ship operating firms. The terms of sale should require an initial payment of not more than twenty percent of the total value of the vessel. The payment of the remainder of the principal sum should be extended over a period of approximately ten years.

The immediate establishment of a national policy for the operation of the American merchant marine is imperative. Until such a policy is definitely determined, neither the banking interests nor the public will be attracted to invest money in the purchase and operation of ships, and failing such investing interests our merchant marine is doomed to failure. With a wise and well defined policy there appears to be no reason why the United States should not possess a merchant marine in keeping with the value of its commerce and its position as one of the leading and dominant countries of the world.

E. C. Bennett, Vice-President and General Manager, Newburgh Shipyards.

THE main points to be borne in mind by the general public are the lessons learned during the war. First of all, it is absolutely necessary that we have a large sea-going merchant marine, not only for the advantages in peaceful trade, but so that we shall not be caught again in a war without ships for transporting men and supplies and as auxiliaries to our navy; and, also, that we shall have trained seamen, deck officers and engineers of American nationality, capable of handling our fleet in wartime.

A consideration of the American merchant marine from a purely commercial point of view brings up the question whether the Shipping Board shall continue to operate the bulk of the ocean-going vessels sailing under the American flag or whether our traffic shall be handled by private ownership. There is no doubt that competition with the other maritime nations will shortly be as acute as ever before, and to be able to compete with foreign ships more cheaply built and more cheaply operated, we will have to have a subsidy or a reduction of import duties on goods carried in American bottoms.

It would be advisable to have a competent Board established, as is the arrangement in England, to revise the laws covering shipping. We have on the statute books, at present, a great many hampering laws written in for the most part by politicians, knowing little or nothing of the business of shipping, or laws promulgated by the labor unions, which make such drastic changes as permitting a sailor to break his agreement and desert the ship at any time. This last is directly in conflict with the laws of practically all the sea-faring nations.

Before the war the average business man's opinion was that, if foreign ships could carry goods cheaper than American ships, without a subsidy, why have a merchant marine? Then came the war, and where did we get off? We rushed into shipbuilding at enormous expense, and managed to build up a merchant marine, by the time the war was over, of considerable size, but at a surplus cost many times greater than a subsidy would have been to have built up this fleet gradually in peace times. The result is that we have a fleet of cargo ships, costing about $225 (46/17/6) per gross ton. We must compete with England, who is building ships at $150 (31/5/0) per ton, and whose pre-war ships cost less than $100 (20/16/8) a ton.

We lost in the war 73 percent of the sea-going steamers that we had in service when the world war was started. We will soon have fourteen million tons of shipping on the high seas, almost all new ships (excluding the captured German vessels). How can we continue to operate them after the present high freight rates have fallen to normal, owing to foreign competition? (This will occur, in the opinion of the writer, in less than three years.) The answer is clear, let the Shipping Board sell the ships to American owners at about $125 (26/0/10) per ton and charge the difference off as a war loss, mainly owing to those obstructionists who have for years passed legislation preventing the normal building up of our merchant marine.

J. Murray Watts, Naval Architect.

MY opinion on the future policy for our merchant marine is best expressed by the following resolution, adopted by the Atlantic Coast Shipbuilders' Association and read before the committee on commerce of the United States Senate:

"That Congress is hereby earnestly requested to proceed at once to the formulation of adequate legislation necessary to maintain an American merchant marine; that in such legislation every discrimination be made in favor of American ships owned, controlled and operated by American citizens, and officered and manned by Americans, whether such discrimination be in the form of duties, tonnage taxes, terminal preferences and incident railroad transportation, or postal and admiralty subventions, or any or all of these, as the nature of the several trades may require, and,

"Be it further resolved:

"That Congress is further urged to provide for a naval or marine wartime reserve, composed of officers and sailors of the American merchant marine, with such rank and pay as Congress may deem fit, or as may be fixed by its accredited agencies, and,

"Be it further resolved:

"That until adequate shipping legislation has been enacted, that Congress is respectfully urged not to authorize the disposal of more than 20 percent of the steel ships of the United States of greater burden than 4,000 tons.

"Be it further resolved;

"That Congress shall provide by appropriate legislation that whenever any steel vessel of more than 4,000 tons owned by the United States, shall be sold by the United States at any time hereafter as hereinbefore provided, such vessel shall not thereafter be conveyed to, nor in any manner controlled by, any foreign citizen, or corporation, except with the permission of Congress, or such public agency as Congress may designate."

R. H. M. Robinson, President, Merchant Shipbuilding Corporation.

IN my opinion, the logical development of the merchant marine can be best accomplished with private ownership of vessels, the operation of such ships, however, to be under the American flag with Governmental assistance and aid for such operation.

The United States Shipping Board should establish a fair and reasonable price for the sale of its vessels to private interests—such price to be standardized and to take

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into consideration the difference between excessive war costs and present values. The Government should charge off this difference as part of its war cost.

In the sale of such vessels care should be taken not to sacrifice the private interests of those citizens who have already purchased vessels from the United States Shipping Board, and an equality should be established which would not give preference to contemplated purchases.

There should be no attempt on the part of the United States Shipping Board to regulate trade routes and rates. If we are to operate a merchant marine in competition with foreign countries, there should be no such restriction, and the business should be based entirely upon supply and demand and competition.

To have the Government sacrifice millions of tons of shipping by the establishment of a receivership and selling to foreign countries such vessels as we have built would be unfortunate for the future upbuilding of our merchant marine, which is so vital and so necessary for the future development of this country.

Ernest Lee Jahncke, President, Jahncke Dry Dock & Repair Company, Inc.

What the Steamship Owners Recommend

(*Concluded from page 288.*)

Successful competition will be entirely impossible, if American vessels are to be capitalized at any such figure as $220 (45/16/8) to $225 (46/17/6) a deadweight ton, at which the Shipping Board now holds its war-built tonnage. The whole case is clearly and briefly stated in this comparison of the charges on capital invested in two similar vessels of 10,000 deadweight tons—one furnished to British shipowners by the British Government at a cost of $100 (20/16/8) per ton, and the other furnished to American shipowners by our Shipping Board at a price of $220 (45/16/8) per ton:

	British Ship ($1,000,000)	*American Ship* ($2,200,000)
Insurance, 3 percent.....	$30,000	$66,000
Depreciation, 5 percent.....	50,000	110,000
Interest on investment, 5 percent...	50,000	110,000
	$130,000	$286,000

Difference in favor of British vessel, $156,000 (£32,000), or equivalent to 15.6 percent on cost of British vessel.

Whatever may be said about the higher cost of wages of American officers and crew as compared with British officers and crew, this difference falls into insignificance as compared with the difference based upon capitalization charges. It is essential to the success of our merchant marine that capitalization and the costs consequent upon it should be equalized—and this fact will be found to be true whether the present Government-owned fleet is turned over to experienced shipowners to operate, with the thrift and enterprise which they best understand, or is retained for operation by the Government. If the United States were to keep these war-built ships and endeavor to compete with the shipping of the world, the first thing the Government would have to do would be to write the cost of its vessel down to $100 (20/16/8) a deadweight ton. If this were not done, and if the Government-owned ships were indefinitely operated at a loss, the American people would insist on abandoning the experiment.

While the difference in the annual cost of maintenance between a British ship of 10,000 deadweight tons and an American ship of the same capacity—the former sold by the British Government at $100 (20/16/8) a ton, or a total cost of $1,000,000 (£205,000), and the latter held by the American Government at $220 (45/16/8) a ton, or a total cost of $2,200,000 (£452,000)—would be as set forth above, $156,000 (£32,000), based on the three essential factors of insurance, depreciation and interest, the difference in cost of maintenance due to the wages of officers and crew would be probably not in excess of $12,000 (£2,460), with a tendency to decrease if British sea wages goes still further toward an equality with our wages.

Equalizing Wage Costs

To equalize this difference in wage cost—which, it must be borne in mind, is a relatively small and probably decreasing factor—our resolution suggests that an allowance of 10 percent of the net earnings of American ships be granted on account of depreciation, and the amount deducted as operating expenses in the tax returns.

Our resolution, moreover, provided that, for the important purpose of directly encouraging American shipbuilding, ships bought from the Board and kept under the American flag be exempted from Federal excess profits taxes on condition that an amount equivalent to such exemption be invested by the owner in the purchase of additional tonnage constructed in American yards. Of all our great national industries, American shipowning and shipbuilding for overseas commerce have been left without aid and encouragement from the Government—other industries, as we all know, having long been protected in some degree or other by national tariff laws. We admit that it must be acknowledged that ocean shipbuilding and navigation are as much entitled as any other industries to some form of national aid against foreign competition.

Our final resolution is:

Resolved, That in the allocation of Government-owned ships that may be unsold after the remainder of the fleet has been disposed of to private ownership and control, preference be given as far as practicable to those American individuals, firm or corporations that already own ships or purchase Government-owned tonnage, and thereby contribute to a complete, privately owned and controlled merchant marine.

In this declaration we do not propose that the Government-owned ships that may be unsold be allocated only to those who already own ships or who purchase the new Government tonnage. We have no desire of suggesting any monopoly of any kind. But we hold that because those who already possess ships or who put their money into the purchase of Government-owned ships and employ them in the foreign trade are directly assisting toward the establishment of a permanent American ocean shipping, and assume responsibilities not incurred by those who only operate and do not buy Government-owned ships, the actual American shipowners should equitably be given a reasonable preference in the further allocation of Government tonnage. We believe that this is a fair and open proposition that, if properly understood, will commend itself to the approval of all men.

National Interests Must Be Conserved

It is our opinion that the majority of the sound concerns now operating Government-owned ships will acquire some of this tonnage if it is offered at a just price, with an assurance of essential national aid hereafter, that the number of American shipowners will be greatly increased by the policy which we have outlined, and that the newly purchased tonnage will be distributed among Atlantic, Gulf and Pacific ports in exact proportion to their needs and opportunities. We stand unequivocally for a broad national interest in shipowning and navigation under the American flag.

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Maritime Legislation Before Congress

Review of Merchant Marine Hearings in Washington—Future Policy Unsettled—Disposition of ex-German Ships

BY WALDON FAWCETT

WITH the approach of a date which will mark the expiration of an interval of a year and a half since the signing of the armistice, there will be occasion for the observer within the industry to be more than ever impressed with the number and variety of the proposals affecting shipping and shipbuilding which await final disposition in the Congress of the United States. If the proportions of this "backed up" mass of Congressional bills be a criterion of the popular interest in the future of the American merchant marine, there may be consolation for the deliberation which the national legislature has shown in passing upon the various suggestions before it. From the very nature of things, the offering of a multiplicity of solutions for any national problem inevitably slows down the selection of anyone.

It is befitting that in the annual review number of MARINE ENGINEERING inventory should be taken, not merely of what has been accomplished during the past month in national legislative aid of the merchant marine, but of the accomplishments of the full twelve months. Looking back over the year, one is impressed with the generous amount of deliberation and discussion that has been bestowed upon the merchant marine issue in its various angles and, by contrast, the total absence of conclusive action. The United States is today as devoid of any detailed, approved public policy on the merchant marine as it was on the day the war ended. Less understandable is the procrastination, which has held off, month after month, the determination of a policy that would permit adjustment of the claims of many shipbuilders who, acting under informal, but wholly regular contracts, contributed to the war fleet or made ready to do so.

MERCHANT MARINE POLICY UNSETTLED

The practical man in the shipping or shipbuilding field, impatient of "the talk" at the Capitol is apt to be especially resentful of the fact that, with all the investigation and discussion that has occurred to date, the merchant marine legislation is not yet "out of committee." That is to say, whereas one branch or the other may have approved this or that legislative proposal there is, on the main issues involved, a divergence of opinion between the United States Senate and the House of Representatives, and consequently the spring of 1920 dawned without any proposition having progressed to that stage of compromise, which must be reached ere any Act can be sent to the President for signature.

There is, however, just this consolation for the industry that, appearances to the contrary notwithstanding, no time has actually been lost by the protracted pondering of the merchant marine issues "in committee." Aside from the fact that, under Congressional procedure, the national legislature is apt to accept, in the main, the recommendations of a committee to which a given subject has been referred, and the further fact that a conscientious committee cannot intelligently make recommendations until it has carefully canvassed all angles of a subject, there was injected into the present situation the deterrent of national railroad legislation.

From the time when it became certain that the railroads of the United States were, in the spring of 1920, to be returned to private management and operation, it was manifest that railroad legislation must take precedence over merchant marine legislation. Knowledge that there would be no impulse to legislate on the merchant marine until the rail transportation situation has been disposed of has doubtless contributed to the leisurely processes of the merchant marine committees of the Senate and House of Representatives, especially the former. At that, though, it is advantageous to have the limitations of the railroad law clearly defined ere the merchant marine legislation is enacted. The two forms of transportation, rail and water, have many points of contact, actual and sentimental, and the terms of the merchant marine legislation may be made the more definite now that the railroad law has clearly indicated jurisdiction that encroaches but little upon water-borne commerce.

DISPOSITION OF GERMAN LINERS

A diversion from the main issues of the merchant marine question, which had its compensations in the direction of public attention to the subject at large, was found in the flurry over the disposition of the German liners. From the standpoint of the industry, perhaps the most interesting practical outcome of the whole discussion of the sale of the ex-German ships was in the information adduced as to present valuations of ship property—estimates made in expression of the replacement prices of the tonnage under consideration. The "very large cost to recondition" (that is, to convert from troop ships to passenger vessels) also received extended attention on the part of John Barton Payne, when, as chairman of the United States Shipping Board, he held consultations with the members of the merchant marine committees of the Senate and House of Representatives.

Late in January, Chairman Payne stated to the President that it would cost possibly $40,000,000 (£8,200,000) to $50,000,000 (£10,250,000) to recondition, presumably in American shipyards, the 30 ex-German passenger ships, which had been used by the United States Army as transports. Later it was desired to obtain more specific information, and accordingly bids were sought on certain representative ships. The actual bids for reconditioning were as follows: the *Huron*, $1,919,093 (£394,000) or $178.70 (£30.5) per gross ton; *Susquehanna*, $382,000 (£78,400) or $38.50 (£7.9) per gross ton; *Callao*, $861,400 (£177,000) or $194.70 (£21.5) per gross ton; *De Kalb*, $3,815,100 (£782,500) or $433.60 (£89) per gross ton; *Moccasin*, $530,000 (£109,000) or $123 (£25.3) per gross ton; and *Æolus*, $2,279,100 (£467,500) or $223.40 (£45.8) per gross ton. It was explained that the relatively high cost on the *De Kalb* was due to the fire on that vessel, which necessitated additional work.

In consideration of whether it was preferable to recondition the ships, or allow them to pass to private ownership in their present condition, the Shipping Board caused estimates of reproduction cost to be made covering twenty of the ships. The reproduction cost, as calculated for the Board was $105,028,445 (£21,600,000). Depreciated according to the age of the respective ships at 5 percent, this left a present value on the twenty ships of $30,738,764 (£6,320,000). On the other hand, the Shipping Board

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had by the latter part of February revised upward its estimate of the cost of reconditioning of the ex-German ships, placing it at $75,000,000 (£15,400,000), the expectation being that six to eight months would be required to recondition.

Commissioner Raymond B. Stevens, who alone of the membership of the Shipping Board stood out for reconditioning the ships, took the stand that just as the Board had refused the pleas of shipping men that the Government sell its cargo vessels at $100 (20/16/8) per ton, and had held out for prices of $200 (41/13/4) to $225 (46/17/6) on cargo ships, other than the old vessels, so the same policy should be followed with respect to the troop ships, namely, that of making sales only when a predetermined price could be obtained. His view has been that the sale of any tonnage, passenger ships or cargo ships, to American shipping interests at prices below the cost of reproduction is equivalent to giving a subsidy. Mr. Stevens has protested vigorously against the initial procedure of the Shipping Board, appraisers in figuring depreciation at the rate of 5 percent flat. In support of his contention he has pointed out that the Government has received bids totaling $6,810,610 (£1,400,000) on seven vessels that, under the 5 percent rule, would have no value at all. Furthermore he recalled that when, during the war, the Government was called upon to pay for ships that were lost, it settled not on the basis of 5 percent flat, but at an approximation of 2½ percent on the depreciated value. When he was asked by Congressmen whether the British do not charge off 7 percent annually for depreciation Mr. Stevens said that he never knew anybody to figure over 5 percent. Most of the shipping companies, he added, figure 5 percent depreciation a year in their operating accounts, but he interpreted that as "a margin of safety," and expressed confidence that no shipping company would figure depreciation on that basis when selling ships.

Cost of Reconditioning ex-German Ships

In the discussions at the Capitol, emphasis has been laid on the fact that the Shipping Board in calculating the cost of reconditioning had relied upon the figures submitted by professional appraisers, and that, in no instance were actual estimates obtained from shipbuilders. As indicative of possible discrepancies, Homer L. Ferguson, president of the Newport News Shipbuilding and Dry Dock Company, was quoted as figuring the reproduction cost of the *Leviathan as* $25,000,000 (£5,140,000) to $30,000,000 (£6,150,000), whereas the Shipping Board estimate gives the reproduction figure on this vessel as $20,000,000 (£4,100,000). Mr. Ferguson was further quoted, at second hand, as having stated that it would cost $450 (93/15/0) to $500 (104/3/4) per ton, right through the list, to replace the German ships, a figure that would, of course, raise the total reproduction figure far above that evolved by the Shipping Board as above outlined.

During the consideration of the merchant marine question in the Congressional committees, and especially the angle of it involving the sale of reconditioned ships, there has been extended conjecture as to the marketable value of "second-hand" ships, in the case of which reconditioning has resulted in the installation of improved equipment and fittings. This discussion was precipitated when Commissioner Stevens, countering on the argument that a "repaired" ship is not as good as one that has not been in need of repairs, said: "I do not know; it depends on how you do the repairs. We got more speed out of the *Leviathan* than the Germans ever did." Commenting on the effect of the proposed reconditioning of the vessels in the hands of the Government, Mr. Stevens said: "These boats would be practically new boats inside throughout, and have very much better power plants than they had before, which would add a considerable amount to the value of the boats." This was not convincing to Congressmen who had been told by practical shipping men that ships do actually "wear out" and that it is in recognition of that fact that it is the policy of the British to get rid of their vessels after they have seen twenty years' service.

According to information that had been given to the Shipping Board, the *Leviathan,* formerly known as the *Vaterland,* could be reconditioned in an American shipyard, but John Dever York, structural engineer of Chicago, appeared before the Senate committee on Commerce to controvert this theory. His claim was that it would be impossible to repair or recondition the *Leviathan* in any American yard, but that it would have to be done in Germany,—not in any German yard, but in the original yard,—"because it is absolutely original throughout." He arrived at this conclusion because, he said, "There is not a line of its hull—there is not a bit of its machinery, there is not a bit of its deck formation that conforms with the ordinary formations of the ships either of the British, the French or the Italian lines." Mr. York suggested that the Bremen builders be invited to come to the United States and survey the vessel. Mr. York, who claims that he had four years' experience on the Clyde, estimating as well as designing, concedes that all of the ex-German ships except the *Leviathan* could be readily reconditioned in American yards, but that the 50,000-ton vessel could not be, because it represents "new thought."

R. L. Hague, director of construction and repair of the Shipping Board, who was for a number of years engineer and naval architect in the service of one of the large shipbuilding companies on the Pacific coast, is confident that the $7,500,000 (£1,540,000) restoration job on the *Leviathan* could be satisfactorily handled in American yards. Mr. Hague has told senators that whereas this vessel could not be drydocked in this country all the work, aside from cleaning and painting, could very readily be done here. In the face of Mr. Hague's statements, Engineer York modified his former deduction that the ship could not be reconditioned in this country. As amended, his opinion was "I doubt whether we could do it properly," and he added to this the prediction that if the work was done in this country it would cost four times what it would if done in the original yard.

The trend in the marine engineering field to oil-burning equipment has been emphasized in the discussions relative to the reconditioning of the ex-German ships. In discussing the case of the *Leviathan,* Homer L. Ferguson remarked that it was "a matter of good business and design" to plan for replacement of coal by facilities for operation by oil. He pointed out that the operation of this vessel with coal had been unsatisfactory or attended with difficulty, owing to her heavy consumption of fuel. Incidentally Mr. Ferguson disclosed the fact that five different American shipyards "loaned" experts and technical engineers to co-operate in the task of preparing plans and specifications for reconditioning and fitting the *Leviathan* as an oil burner. He remarked: "It is a tremendous job, almost as big a job as designing and planning and building a ship in the first place."

As indicative of the confidence of American shipbuilders in the future of the American merchant marine, facts have recently been laid before the senate commit-

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tee with respect to "adjustments," whereby representative shipbuilding firms are to proceed, on their own account, with the construction of vessels the contracts for which had been cancelled by the Shipping Board. Typical of the negotiations lately concluded was that with the Toledo Shipbuilding Company. Three of their ships were cancelled. They had cancellation claims amounting, as Chairman Payne put it, to $560,000 (£115,000) in one case and $120,000 (£24,600) or something like that in the other case." The Shipping Board, as he relates it, had made payments of $218,000 (£44,750) on account of the cancelled ships and had $161,000 (£33,100) worth of materials in the yard, representing steel fabricated for these cancelled ships. The ultimate settlement is on a basis of $600,000 (£123,000). That is, the shipbuilding company retains the money that has been paid; acquires possession of the materials on hand and receives the balance in cash. In the case of the Terry Shipbuilding Company the execution of the contract with the Shipping Board as originally entered into would require an expenditure of $4,125,000 (£847,500). Instead of that the corporation took over the unfinished ships on a basis whereby the Government is allowed $4,000,000 (£821,000) net against its contract obligations. Commenting on the disposition of shipbuilders to turn around in this wise, the Chairman of the Shipping Board said:

ADJUSTMENT OF SHIPBUILDERS' CLAIMS

"We are making trades of this sort right along, and we find a disposition on the part of the shipbuilders to make the trade. For instance, the Northwest Steel Company, of Portland, Oregon, had a contract with us to build a certain number of cargo ships. They had a claim for cancellation of $3,000,000 (£616,000). We made a trade by which they, instead of building those ships, take a contract to build 10 tankers to be sold to a ship company, and in that way we got rid of our $3,000,000 (£616,000) loss on cancellation charges, and we helped finance the building of the shipping, and take a mortgage on the ships. The point of this is that there is a disposition on the part of the shipbuilding companies to go forward and build ships, and we are encouraging them all we can. We make no limitation as to registry. If a shipbuilding corporation wants to build ships for foreign account we help them all we can."

All the information reaching the Shipping Board is to the effect, senators have been advised, that even the corporations established during the war intend to remain in shipbuilding operations or to turn over their plants to new interests that will carry on. The case of the yard at Wilmington, N. C., has been instanced. There was consternation in local business circles at Wilmington when the Shipping Board cancelled its contracts for four vessels, but negotiations were concluded whereby the George A. Fuller Company is to build the four vessels and that corporation will, if its present intentions are adhered to, continue permanently a shipbuilding plant at Wilmington.

As has been indicated in the "progress reports" published from month to month in MARINE ENGINEERING a goodly share of the merchant marine legislative program has been devoted to discussion by authorities who have appeared at Washington, voluntarily or by invitation, to express opinions as to the conditions under which Government tonnage should be transferred to private ownership. The problem of the proper "write-off" from wartime costs has revealed an especial divergence of opinion. A very interesting aspect of the existing situation was revealed, also, to the senate committee by Charles W. Morse when, in relating that he would like to buy 100 additional ships from the Shipping Board at a price of $220 (45/16/8) per ton or thereabouts, he expressed the conviction that he could operate these ships and make money on that investment provided "the Government will not become a competitor and reduce the prices." The veteran shipping man made it clear that he was not afraid of other competitors but only of the Government. "If the Government keeps up their prices of freight," said Mr. Morse, "there is no danger in a man buying."

TERMS FOR SALE OF GOVERNMENT SHIPS

The terms of sale applicable to Government tonnage have been the subject of considerable discussion. Mr. Morse stated, at one point, that he regarded the terms now demanded as onerous. In the case of the 24 vessels which the Morse interests had contracted to build for the Government, and which, it has taken over on terms that allow the Government to get back all its costs, all its overhead and interest on its money, the conditions of payment call for 25 percent down on delivery of the ships, 12.5 percent in 6 months; 12.5 percent in twelve months; and the balance 6.25 percent every six months, allowing five years for the discharge of the obligation. However, Mr. Morse has made it clear at Washington that he could not take on the additional one hundred ships for which he has spoken on terms so stiff as the above. Instead of 25 percent down, he would like to see the down payment comparatively small, say 5 percent, and all net earnings for the first year to be applied to the purchase, with the balance spread over a reasonable number of years. Mr. Morse was inclined to endorse the tentative plan evolved by the Shipping Board, which would call for payment to the Government for vessels sold at a rate of $8.30 (1/14/7) per deadweight ton per month.

Vigorous dissent was offered by Mr. Morse to the theory repeatedly advanced before the Shipping Board that the cost of ship construction is to drop precipitately, and that even to-day, contracts can be placed in foreign yards at figures far below those that rule in the United States. He recounted an offer recently made to him by foreign interests of $185 (38/10/10) per ton to build three vessels of 9,400 tons for delivery eight months hence. As to values, his feeling is that a vessel to-day at $225 (46/17/6) a ton, is a better buy than one at $185 (38/10/10) a ton a year hence. His idea is that a shipowner may, by taking advantage of the current high freight rates, get nearly 50 percent of the cost of his vessel during the first year of operation. In other words, he would enter his second year of operation on the basis of an investment of not to exceed $125 (26/0/10) to $135 (28/2/6) per ton, and could face with equanamity the prospect of a reduction of rates in response to the functioning of the law of supply and demand after the scarcity of foreign tonnage has been relieved.

The opinion freely expressed to Congressmen by experienced shipping men that a goodly portion of the uncompleted wooden tonnage in newly established American yards ought to be "junked" or converted into barges, after engines and machinery were salvaged, has its influence upon the enactment of legislation for the adjustment and payment of the claims of wooden shipbuilders. The two branches of the national legislature have been in agreement on the basic principle that the equitable claims of the wooden shipbuilders should be granted, but there have been differences of opinion as to the precise wording of the authorization to be given to the Shipping Board.

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The Present Trend of Marine Engineering

BY LIEUTENANT-COMMANDER H. G. DONALD, U. S. N.

During and since the recent war, interest in marine engineering has developed in this country to a high pitch, which is destined to be maintained. Of the benefits derived from the war, one of the most important is the impetus given to the building of a merchant marine worthy of the large volume of foreign trade of this country. Another is the unusual activity in naval construction. In this article the author gives a clean-cut, comprehensive review of the present developments and future trend in marine engineering as influenced by these conditions.

BESIDES the experience gained and the lessons taught by the war, the United States Navy has added to its fleet over two hundred and fifty destroyers in which are incorporated, despite their rapid construction, all that is latest and best in engineering to suit their needs. The building of the battleships, battle cruisers and scout cruisers, planned just before our entrance into the war, has necessarily been delayed, but is now being prosecuted. The machinery of these vessels constitutes the highest development for installations where very large powers are required, and is, therefore, of as much interest to-day as it was when it was planned. In fact, the planning and improvement of these installations were continued throughout the war and are only now nearing final settlement. The destroyers laid down by this country in such numbers to answer the Hun submarine problem are not yet all delivered, and their engineering characteristics are up to the minute for very light weight, high powered requirements.

The War Creates a Merchant Marine

The American merchant marine as it stands to-day is purely a product of the war. The majority of the vessels were built for the Emergency Fleet Corporation. Due to the necessity for quantity production of cargo carriers on a large scale, the standard ship was evolved. If it had been possible in this country, as it was in Great Britain where the shipbuilding industry was so well developed, the regulation merchant vessel equipment of triple expansion, recriprocating engines and Scotch boilers would have been installed in practically all ships. As it was, although all facilities for the manufacture of the regulation engines and boilers were used, and the Government contracted for shops and even whole plants for the manufacture of Scotch boilers, still the demand far exceeded the supply and the old standard installations were supplemented by large and small tube watertube boilers, geared turbines and internal combustion engines. Thus there were adopted for merchant use, machinery and boilers which in the ordinary course of events would not have come into general use for several years.

The merchant sea-going engineer is loath to take up "new-fangled" ideas. It is only natural that he should be more averse to them than his brother ashore who can obtain the advice of experts or the services of the manufacturer's repair men by sending a telegram or using a telephone. In a ship, when she leaves the dock, the engineer must be sure of his machinery; for he is entirely independent of outside assistance, and, in addition, there are the perils of bad weather should a mishap occur. The wireless telegraph has done a great deal to allay these apprehensions.

The personnel situation in the merchant marine, particularly in regard to engineers, is a very serious one even now. The inability of personnel of little experience to operate the newer types of machinery has caused much destructive criticism where it was not deserved. While the failure of a new type of machinery is spread broadcast, that of the old is not considered to be of sufficien importance or interest to warrant discussion, and it is not generally heard of. But it may be safely stated that there have been as many casualties with the older types of machinery as there have been with the newer ones. One point in regard to inexperienced personnel that is worth bringing out is that this same inexperience and newness to marine engineering will make the operating engineers more receptive of the more advanced ideas than would engineers that had been brought up at sea.

The increasing cost of fuel is compelling shipowners to seek for and to adopt any improvements in machinery installations that will give economy, providing reliability is established. The recent development of marine machinery has been along the lines of securing greater efficiency of the unit and greater economy in overall operation. There are some who will say that a number of the late improvements have still to prove their reliability. Recent development has not been in the nature of making machinery more complicated, but just the reverse, and it can be stated from personal experience that the operation and upkeep of a highly modern installation is a much easier task than that of caring for one of the same power, built along the lines in practice ten years ago.

Machinery for Main Propulsion

The various types of machinery in use to-day for main propulsion are as follows: Reciprocating steam engines, turbines, direct connected; turbines, with mechanical single or double reduction gears connecting them to the propeller shafting; turbines, driving electric generators which in turn supply current for turning motors connected to the propeller shafting, either direct or through mechanical reduction gears; internal combustion engines connected to the propellers direct or through mechanical or electrical reduction.

The Reciprocating Steam Engine

The reciprocating steam engine is the old standard propulsive machinery for merchant vessels of the cargo type. This engine has been developed to what may be considered its maximum efficiency. For slow ship speeds and low powers it has much to recommend it from its reliability. The usual type is triple expansion, three-cylinder vertical, inverted cylinders. Quadruple expansion is also in use. One of this type is that found in specifications for the latest Shipping Board cargo vessels of 10,000, 12,000 and 15,000 deadweight tons. The engines to be used are quadruple expansion, four-cylinder, using the Yarrow-Schlick-Tweedy system of locating crank angles for balancing. An economical figure of .83 pound of fuel oil per indicated horsepower-hour is claimed. The modern naval reciprocating engine is triple expansion, four-cylinder (two low-pressure cylinders), arranged in

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the order of forward low pressure, high pressure, intermdiate pressure and after low pressure, and fitted with forced lubrication for all bearings including valve gear. In general use to-day are the Stephenson link gear, piston valves on the high pressure and intermediate pressure cylinders, and balanced double-ported slide valves on the low-pressure cylinders (piston valves in the Navy), straight, short ports giving minimum cylinder clearances and the lowest possible steam velocities. The strokes used for slow speed cargo vessels are: 36 to 40 inches for engines of 1,000 to 1,250 indicated horsepower, 40 to 48 inches for engines of 1,300 to 1.800, and 48, 54 to 60 inches for larger sizes. The revolutions per minute with reciprocating steam engines for ship speeds of 9 to 12 knots are 90 for indicated horsepowers up to 3,000 and 80 down to 65 for indicated horsepowers of 3,000 and up.

Without question, the navies of the world have been the clearing houses for the development or rejection of new ideas in marine machinery, and this is one of the important peace-time functions of the United States Navy. Not only are various inventions and improvements given a trial under conditions where the operators are above the standard of the merchant operating personnel, and where their true worth is demonstrated beyond a doubt, but also the necessary encouragement is given the machinery manufacturers of the country under conditions simulating government subsidy. The Government itself does a great deal of experimental and research work which has helped the art of marine engineering. Of course, there are certain conditions for which naval machinery must be designed which are not met with in merchant practice, notably, design to provide for economy at low power (cruising speed), and duplication of units, but, in general, the most up-to-date naval practice may properly be considered to be the future trend of merchant vessel machinery. It is hardly likely that any types of propulsive or auxiliary machinery or boilers will be introduced into the merchant service which have not first been proven to be successful in the Navy from the standpoint of both economy and reliability.

Development of the Steam Turbine

In 1905, the Navy Department determined to try the turbine for marine propulsion. Three scout cruisers were authorized, one to have reciprocating steam engines on two shafts, one to have Curtis turbines on two shafts, and one to have Parsons turbines on four shafts, all using direct drive of the propeller. On trial of these vessels, the reciprocating engine showed up to better advantage than either turbine. However, the results obtained and subsequent improvements in design warranted further trial of the turbine in other vessels.

During the tests of the next few years it still appeared that the reciprocating engine was better suited than the turbine for marine use. This was because the designers of the turbine lost sight of economy of propulsion and aimed only at securing economy of the turbine. A number of methods of securing economy of the turbine at cruising speed were developed, including extra turbines for use at low power only and a combination of turbine and reciprocating engine. These methods prevailed until the development of reduction gears.

By the introduction of such gears, whereby the turbine speed could be kept high at all speeds of the vessel and the propeller speed kept low, large increases in the economy of propulsion resulted, with the further result that the turbine firmly established itself in favor. This discussion applies to cargo vessels as well, for it must be remembered that the cruising speed mentioned is around twelve knots.

This variation of turbine and propeller speed has been accomplished in two ways—by mechanical reduction using helical gears and by electric reduction having the turbine drive a generator which drives electrically a motor on the propeller shaft. The first trial of the mechanical reduction gear in the United States Navy occurred in 1910, and the trial of the electric drive was in 1911, the ships used being naval colliers. Both of these trials were highly successful; and although there have been a number of direct-connected turbine installations put into naval vessels since that time, this method of drive is now no longer considered. The few destroyers built during the war at Newport News with direct drive of main turbines and geared cruising units were only allowed because of the difficulty of securing the gears for the main turbines; all of the remainder of the destroyers built during this time have geared main turbines.

Reduction Gears

In the naval service, it is now standard to use mechanical or electrical reduction on all vessels that are to be operated by a naval crew. Electrical reduction is used only for capital ships, i. e., battleships and battle cruisers. Both the reliability and the economy of the turbine have been established from a naval point of view. Geared turbine drive on destroyers has raised the economy of propulsion at cruising speeds over 30 percent, and in larger vessels the saving, while not so great, is a very substantial figure.

The 20,000-ton, 28,000 shaft horsepower battleship *North Dakota* is an interesting case where the main turbines have been of both types. The original turbines were direct drive, installed in 1910, and were replaced in 1918 by mechanical-geared turbines, one high pressure and one low pressure on each shaft. It is stated in the last annual report of the chief of the Bureau of Steam Engineering that the gain in economy of propulsion effected has amounted to 31 percent at practically all speeds.

If it were not for the turbine itself, such high powers as are in use or contemplated on battleships, battle cruisers, scout scruisers and destroyers would be out of the question. For example, the powers to be used and in use in our latest high speed warships are as follows: Destroyers (35 knots), 28,000 shaft horsepower; battleships (23 knots), 60,000 shaft horsepower; scout cruisers (35 knots), 90,000 shaft horsepower; battle cruisers (34 knots), 180,000 shaft horsepower. Truly these are stupendous and almost unbelievable figures, if viewed with the light of five years ago. Speeds as high as 39.7 knots (H. M. S. *Tryon*) have been obtained with turbine installations in destroyers. As high as 25,000 horsepower per shaft, and 15,000 horsepower per pinion are now in use.

Efficiency of Mechanical Reduction Gears

The efficiency of the mechanical reduction gear has been the subject of much discussion, but, with good design, a figure of 98½ percent for single reduction and 97 percent for double reduction gears at full power seems safe. The angle of the teeth has been reduced from 45 degrees to 30 degrees in a number of recent designs and a small

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pitch appears to be preferable to a large one, provided the tooth pressure is not allowed to go too high. In general, gears have been satisfactory in service, and cases of failure can all be traced to hurried manufacture, defective material or carelessness in operation. Pitting of the teeth, due to excessive local pressure causing spots of small diameter to flake off, has not affected the working or the life of the gears. The most successful gear manufacturers use horizontal machines for cutting gears and some have an attachment for causing the table to creep, thereby discounting any small error in cutting which would otherwise produce objectionable vibration and noise when the gear is in use.

Not only has the geared turbine proved to be an unqualified success in naval vessels, but also it has been taken up extensively for the propelling machinery of merchant vessels of both cargo and passenger types. Once its reliability is established beyond a doubt when operated by a merchant crew, it will be the only design considered where steam is to be employed, with the possible exception of turbo-electric drive, and where the prospective operating personnel is of a low order. Of all the vessels operated by the Shipping Board, 40 percent are geared turbine drive.

Troubles With Geared Turbines

It is reported that a great deal of trouble has been experienced with the gears of these vessels, and it is because of this that the Shipping Board in its latest vessels is considering only the quadruple expansion, reciprocating steam engine. In all fairness to the gear manufacturers, it must be stated that these troubles were due either to the hurried manufacture of the gears under stress of war conditions, demanding the full capacity possible of the shops, or were due to the inexperience of the operating engineers, who probably would have come to grief with reciprocating engines.

Lubricating Systems

A material aid to the successful operation of the geared turbines on merchant ships is the new arrangement of the lubricating system being introduced into these vessels, and troubles undoubtedly will be less frequent when it is adopted on all geared turbine ships operated by merchant crews. Lubrication of the main propelling plant is a very important item in any system, but it is of paramount importance in turbine drive, whether direct or geared. The choice of lubricating oil is well handled by the large lubricating oil companies, and, for the merchant service a ship is hardly likely to get the wrong kind of oil for the type of engine installed.

The system of lubrication originally installed on merchant ships has not proved altogether satisfactory, and the failure of many geared turbine installations has been due to this fact. In the naval service, it is standard practice to supply the lubricating oil by duplicate pumps under pressure direct to the bearings and gears. This method has proved a most satisfactory one, and there are few cases of failure of the system. In the merchant service it has been found necessary to install tanks of a considerable capacity at a height above the engines that will insure a proper pressure on the system to the bearings, 20 feet, or about 10 pounds being considered a minimum figure. The tanks are fed by the forced lubricating oil pumps and an alarm (float type, electric) is fitted on the tank to give due warning when the supply is getting low.

For merchant practice, two methods of installing the pumps have been used; one, with the pumps driven from the main shaft, and, the other, with pumps having independent drive, which are provided in duplicate. Strainers in the oil discharge piping are always installed, and, in naval practice, in the suction piping also. The application of the centrifugal separator, first used for the separation of cream from milk, for the renovation of lubricating oil marks, really, a great advance in lubrication and eliminates many of the troubles that appear only in marine installations

The separator removes from the oil both water and sediment in a most efficient and expeditious manner, even when salt water has formed an emulsion with the oil, and delivers the oil in the same state as when new. These separators are being installed by the Navy wherever forced lubrication is used. When used properly and regularly, they safeguard the bearings by making it possible to keep the oil continuously in good condition, and there is no reason why, with due care, the bearings should show any appreciable wear even after years of service.

The money value in oil saved has made their installation in naval vessels well worth while. The method in general use of settling out sediment and water by heating the oil in settling tanks is not nearly so satisfactory in that the separation of the impurities from the oil is not complete, the time for settling with any results at all is comparatively very long, and the tanks required are cumbersome.

The single reduction gear is in use where the ship speed is above about 14 knots. For speeds below that, the double-reduction gear is usually found. The average cargo ship recently built has a propeller speed of 90 revolutions per minute for geared-turbine drive.

Balance of Turbines, Gears and Propellers

When using high-turbine speeds, as in reduction geared installations, the matter of securing a good degree of both static and dynamic balance is of much importance. This matter has been taken up by the Navy at a recent date, and although only a few installations have been scientifically balanced, the necessity for it is recognized, and it will become standard practice. The most successful balancing has been done by the Mare Island and New York Navy Yards, where not only are the turbine rotors balanced, but also the pinions, main gears, shafting and propellers. The perfection of balance obtained has been such that when the turbines are driven at 20 percent over speed (with propeller shafts disconnected), the vibration is so small as not to shake down coins standing on edge on the bearing-cap bolts. Destroyer geared turbines which have been balanced show an increase in efficiency over those which are not, while the vibration of the hulls becomes reduced to a neglible minimum. Proper balancing also has a marked effect on reducing repairs to the turbines.

Thrust Bearings

In connection with the geared turbine, due credit must be given to the Kingsbury thrust bearing in this country, and to the Michell thrust in Great Britain. This type of bearing makes possible the use of a single collar. It gives a decided improvement in the mechanical efficiency, saves space and weight and gives economy of lubricating oil. It is suitable for use with any type of propulsion. While it has not by any means come into general use in the merchant service of this country, there are a few vessels in which it has been installed. The reason for it not being adopted on a large scale is the same reason that holds back the geared turbine, i. e. lubrication—oil must be supplied continuously. In the naval service, it has become the standard thrust bearing with the building of the *Tennessee* class of battleships. All destroyers built during the war are fitted with it, and, in fact, had it not been available, serious difficulty would have been met with

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in finding sufficient space for the old horseshoe type. The General Electric turbines supplied to the Navy have used their type of single-collar roller thrust bearing on the turbines themselves.

The bearing pressures used in the Navy for the horseshoe thrust were from 62 to 74 pounds per square inch, whereas, with the Kingsbury, the thrust pressures run from 291.5 to 425 pounds per square inch. The 425 figure, is found on the new turbine installation of the *North Dakota*, where these bearings have been particularly successful.

Hydraulic reduction gear is in use on some German ships (Föttinger type), and has also been tried experimentally in the British Navy. It is not used in this country in either the merchant marine or navy.

TYPES OF TURBINES

The two general types of turbines in use are the Parsons and the Curtis, with modifications of both. In America, the Curtis is found in more installations than is the Parsons, both in the navy and in the merchant service. However, the Parsons installations in the Navy have all been most successful, and the more general use of the Curtis is rather a question of its having been developed on a larger scale by the manufacturers in this country than has the Parsons. The design of blading and particularly the method of securing blades in the rotor have been much improved. In England it is usual to find the Parsons turbines that have recently been built fitted with an impulse type of first stage, in order to reduce complications due to very short first-stage blades, and consequent high percentage of leakage past the blades.

ELECTRIC DRIVE

Another method of obtaining both high propulsive efficiency and high turbine efficiency at the same time is the reduction by means of electricity of the speed of the propeller below that of the turbine shaft. This system of propulsion offers such great advantages in the matter of location of the machinery to obtain maximum protection from damage due to underwater attack that it has recently been adopted by the Navy as the standard for capital ships, i. e. battleships and battle cruisers. The engineering features have been well developed by both the General Electric and the Westinghouse companies, and this country is much farther advanced than any other in knowledge of the details of design and manufacture connected with such installations.

So far, the only cargo vessel in America on which it has been installed is the *Jupiter*. This vessel was the one selected by the Navy for the demonstration of electric propulsion, and the result of about six years' service has demonstrated the reliability of the system beyond a doubt. It was after the successful test of the *Jupiter* that the design was adopted for the *New Mexico* and later for twelve battleships and six battle cruisers now building. At present the Navy does not contemplate the installation of electric drive on any vessels except capital ships.

The Coast Guard Service is placing this drive in two of the five 1,600-ton, 2,600 shaft horsepower cutters now building, the other three ships to have mechanical-geared turbine drive.

In England, electric drive has not received much attention, although one merchant vessel is so fitted. On the British *K*-class submarines, it has been adopted for use immediately after coming to the surface or just before submerging, the motors being driven at this time by Diesel engines. When operating normally on the surface steam turbines are used and when submerged, of course, the motors are operated by batteries. In Sweden, seven vessels are being fitted with Lungström turbo-electric drive; two are of 1700 horsepower, and five of 1200 horsepower.

It is understood that the Shipping Board is considering installing electric drive on some of its cargo vessels. For merchant service, the Diesel electric drive is looked upon by some with more favor than the turbo-electric combination. An interesting recent installation of this character is on a trawler just put in service on the New England coast.

ADVANTAGES OF ELECTRIC DRIVE

The merits of the electric-drive system as applied to naval capital ships are well stated by Admiral C. W. Dyson, chief of the design division of the Bureau of Steam Engineering, Navy Department, in the May, 1917, issue of the *Journal of American Society of Naval Engineers*. It will be seen that many of the advantages stated apply as well to merchant vessels.

1. Greatly increased torpedo protection for ships.
2. Greater flexibility in machinery arrangement.
3. Better and wider separation of important units.
4. Minimum lengths and diameters of steam pipes.
5. Reduced heating of vessel from steam pipes.
6. Better centralization of power.
7. Fewer bulkheads pierced by steam and feed piping.
8. Reduced engine room complement.
9. Elimination of danger from fractures of piping due to shells striking protective deck.
10. Greater ease in control.
11. Greater flexibility in power distribution.
12. Better maintenance of economy through a wide range of powers.
13. No metallic contact between rotor and stator of motor.
14. Eliminates all dangers of disarrangement due to shaft vibration, when the helm is put hard over.
15. Maximum reduction in length of shafting.
16. Increased backing power.

The internal combustion engine for ship propulsion has not received the stimulus that it deserves in this country. The Shipping Board has two vessels in service equipped with Diesels, one a 4,500 indicated horsepower Burmeister and Wain and, the other, a 3,000 indicated horsepower McIntosh and Seynour installation. It has been proposed by the Shipping Board to install this type of engine in ten other vessels.

MOTORSHIPS

Very few vessels are equipped with internal combustion engines of over 1,000 horsepower per set. However, that there is some and increasing interest taken in this country in the Diesel engine for marine propulsion is shown by the fact that most of the large shipbuilding companies are obtaining licenses to manufacture foreign designs and a few are developing engines of their own design. The war caused a setback in the development of the Diesel for commercial work, which will make it more difficult for it to catch up with the geared turbine. Considerable experience was, however, gained during the war in the building of heavy oil engines for submarine work, and undoubtedly, the high cost of fuel will force it to the front in considering types of propulsion of future cargo ships.

PROPELLERS

The form of the propeller in use to-day is the same that has been in use for years, that is, the true screw is still considered to be the proper form and the many inventions and attempts to improve on it have come to

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nothing. However, the method of preliminary determination of pitch, diameter and projected area has been so improved that predicted performance checks up very accurately with actual results where the form of hull is known in advance.

BOILERS

The main features in boiler development for marine use have been the introduction of the watertube boiler into merchant ship work, the great extension in the use of fuel oil in place of coal and the development of the small-tube boiler of very high capacity for naval purposes.

Upon the entrance of the United States into the recent war, when the construction of merchant vessels was taken up by the Government on such a large scale, it was impossible to secure a sufficient number of the standard marine Scotch (or firetube) boilers, and it became necessary to call on manufacturers of watertube boilers to outfit many of the new vessels. As a result, of the total number of boilers in the Emergency Fleet about 56 percent are watertube and about 44 percent are firetube. The watertube boiler is forcing recognition as the superior type for merchant work, and one hears more and more of its merits. This is especially true where oil fuel is used and where pressures over 200 pounds gage are necessary. However, the specifications for new cargo vessels recently issued by the Shipping Board call for the boilers to be single-ended Scotch, steam pressure, 220 pounds gage, 100 degrees F. superheat and oil-fired.

A large number of types of watertube boilers are found in recently constructed merchant vessels, and the type in most general use is the Babcock and Wilcox, with the Emergency Fleet boiler a close second. The customary evaporating rate used in merchant work is 5 pounds steam per square foot heating surface for both watertube and firetube boilers, whether oil- or coal-fired.

Mechanical stoker firing of watertube boilers has received practically no encouragement, although there is no apparent reason why some of the designs which have met with such success ashore should not be developed for marine purposes. The Navy has not attempted to develop it because of failure of existing designs to stand up when the vessel is rolling, because of the sudden and frequent variations in load required when ships are steaming in formation, and because of the adoption of oil as fuel. The use of mechanical stokers on merchant ships will probably come when the price of coal drops, for the advantages of mechanical stoker firing are many where the load is constant hour after hour, and where the firemen are more apt to be inefficient.

NAVAL BOILERS

In the naval service the large tube watertube boiler is the standard for all installations except where, on account of limited space or weight requirements, the use of the small-tube express-type boiler is mandatory, and in auxiliary vessels which have merchant crews where Scotch boilers are still installed in a few cases.

Upon the adoption of oil fuel for naval boilers, the Babcock and Wilcox Company, in order to meet the demands of the Navy, modified their boilers as follows: The side-water walls were eliminated, heavy fire brick walls being substituted; the angles of the tubes and headers were changed, tubes from 15 degrees to 18 and 20 degrees and headers accordingly; outside downcomers were installed between the steam drum and the lower front crossbox; the lower row of 4-inch tubes was done away with and two rows of 2-inch tubes substituted. At a very recent date it was found necessary to modify the baffle in the steam drum in order to prevent priming at very high rates of steaming for this type of boiler.

In addition to the new express boiler designed by Admiral Dyson, which is made mention of later, improvements have been made in an express boiler of the White-Forster type, fitted with superheater. On test at the fuel-oil testing plant at Philadelphia in May, 1919, this boiler (total heating surface 8,353 square feet) obtained an evaporation of approximately 23 pounds of water from and at 212 degrees F. per square foot of heating surface with an equivalent evaporation of 15.3 pounds of water per pound of fuel oil. This is a record high capacity performance. It is of much value in that it proves that the express-type boiler may be forced, without danger, to a much higher capacity than was formerly thought possible. In the battle cruisers, scout cruisers and latest type of battleship where very high powers are used, adherence to former practice would have made the boiler weights prohibitive.

FORCED DRAFT

Forced draft is becoming more general in merchant ship boiler installations, whether using oil or coal fuel. The air pressure is 2 inches of water regardless of the fuel. For coal, the Howden closed-ash-pit system is used and for oil the air is supplied by ducts led to each individual burner. In the naval service, a pressure of 2 inches of water is used for coal and 6 to 9 inches for oil. Eight inches has been recently adopted as the standard pressure for capital ships in order to prevent flare back of oil flame into the fire room due to the blast down the smoke pipe from heavy gunfire. On the new 35-knot destroyers, one often sees as much as 9 inches air pressure in the fire rooms when the boilers are driven at full power. Naval practice has always been to use the closed-fire-room system of forced draft, and this will undoubtedly be adhered to in the future on account of safety and comfort, although the air leakage is in design estimated at 50 percent notwithstanding the great care in construction given to secure air tightness of compartments. In the latest capital ships, this figure is probably too high, for each boiler is in an individual compartment and the only access is through a well-constructed air lock.

Steam pressures have not been materially increased. In the naval service, the tendency has been, if anything, toward a slight reduction in pressure. In the merchant service it is, however, now common to use pressures of from 200 to 250 pounds gage, about 220 pounds being the usual figure. Of course, when watertube boilers are installed the pressure is apt to be higher than when firetube boilers are called for.

SUPERHEATED STEAM

The use of superheat is becoming recognized to be well worth while from the material increase in economy that is realized, and an increase in the amount of heat per pound of steam available for useful work is being obtained by superheat rather than by increase of pressure. In the Navy, superheat was introduced in recent years in the *Michigan* class of battleships and continued into the *Delaware* class only to be dropped, on account of the use of Parsons turbines, and then to be taken up again in the new battleships and battle cruisers now building.

In the battle cruisers particularly, where it was necessary to install an express-type (small tube, large angle of inclination to the horizontal) boiler, and as there was only one boiler of this character on the market to which superheaters were adaptable, the Bureau of Steam Engineering designed a boiler especially for the purpose. This

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boiler was brought out by Admiral Dyson, and the particular feature of design is that the superheater is nested in the generating tubes, but in such a manner that it can be rolled out for the renewal or inspection of tubes.

Superheats of 100 degrees F. are common in this country. In England the tendency is to use 200 degrees. All of the later Shipping Board merchant ships are fitted with superheaters. This applies for both turbine and reciprocating engines, watertube and firetube boilers. The Shipping Board prefers the waste-gas type superheater for watertube boilers, while the Navy installs the superheater at the end of the first gas passage in a baffled watertube boiler. In firetube boilers the most favored superheater consists of tubes laid within the upper rows of generating tubes.

Fuel Oil Burning

Fuel oil may now be taken as being the standard fuel for the Navy for all types of vessels. In the merchant service fuel oil is most popular, as is indicated by a survey of the ships operated by the Shipping Board, where of those fitted with reciprocating engines 70 percent burn fuel oil and of the turbine ships 55 percent use this fuel. Some interesting figures in this connection are the standard fuel allowances per horsepower-hour for the various types of ships in the Emergency Fleet. These figures are used for checking fuel requisitions and the performance of vessels.

Type Engine	*Fuel Used*	*Standard Fuel Allowance in Pounds Horsepower Hour*
Reciprocating	Coal	2.41
	Oil	1.25
Turbine, geared	Coal	2.0
	Oil	1.0
Diesels	Oil*	.39

*Includes 150 horsepower boiler in use for steam heating.

Important points in the development of fuel oil burning in the Navy are as follows: The superiority of the Bureau of Steam Engineering and the Peabody types of registers and atomizers has been demonstrated beyond a doubt by test and service use. The Bureau register may be used for either forced or natural draft.

A large variety of types of registers and atomizers are in use in American merchant ships. The Shipping Board vessels alone have fifteen types installed and the tendency there is to use natural draft burners. The new naval general machinery specifications provide that the center of the register must be 22 inches from tubes or sides or bottom of furnace. Specifications for latest naval capital ships make provision for a maximum of 10.8 pounds of oil to be burned per cubic foot of furnace volume. The matter of having a sufficiency of furnace volume has been found to be one of utmost importance if good combustion is to be obtained.

Auxiliary Machinery

Improvements in the design of auxiliary machinery have kept pace with the advance of main propulsive machinery.

Condensers

The standard style of condenser that has been in use for years is still the rule. However, a number of modifications have recently come into use. The cross section is either circular or pear-shaped. Merchant practice uses straight ¾-inch tubes packed at both ends, naval practice uses straight ⅝-inch tubes expanded into the tube sheet at the entering-water end and packed at the other, or curved ⅝-inch tubes (destroyers) expanded at both ends. Two passes of the circulating water are the rule in merchant and naval ships except destroyers and scouts which use one pass. In merchant practice the water enters at the top in some and at the bottom in others. Latest merchant ships are provided with two injections, one high for use in shoal, smooth water, and one low for use at sea. On all the lake steamers that were brought to the seaboard for use in trans-oceanic service it was necessary to fit a low injection as the one installed rolled out of water when the ship was in a seaway.

Naval two-pass condensers recently constructed have spherical heads. It was found that the flat head gave too little area for change of direction of flow of water at the reversing end. In the latest naval condensers the cooling surface per horsepower has been decreased and circulating water considerably increased.

The only departure worthy of mention from the standard arrangement of tubes and steam flow is the Lovekin patent condenser. This is a special design with tubes and steam space baffling so arranged as to provide, by use of drip sheds, for a minimum loss of effective cooling surface by drowning of the lower tubes from condensed steam dripping from the upper tubes and to provide for a central vertical chamber in the tube nest from which the air ejector takes suction, the chamber being open to radiating passages which draw from all parts of the lower half of the condenser. This type of condenser is being installed in the battleships *Tennessee, California, Colorado* and *Washington*. It is also to be used in twelve Army transports building at Hog Island. One of the latter vessels is now testing the condenser. It is expected that the vacuum desired will be obtained with a considerable reduction in cooling surface and circulating water over the old type without special baffling in the steam space. Also it is expected that the vacuum obtained at the top of the condenser will more nearly equal that at the air ejector suction.

Pumps

For air pumps the Edwards type is still the favorite in the merchant service for both turbines and reciprocating engines and for the latter is operated by the engine. There are, however, a few installations of the air ejector—condensate pump type for turbine installations. This latter system is the only one considered for the latest capital ships of the Navy, both on account of the great saving in space and weight and also on account of the ease with which a high vacuum may be maintained.

The augmenter type of ejector discharging into a special condenser connected to the suction of a reciprocating air pump has been, in some cases, displaced by the two-stage ejector, discharging to an air separating space in or above the main feed and filter tank. In this type, all heat in the steam used for operating the ejector may be reclaimed in the feed water. Inter-condensers are sometimes installed between the first and second stages of the ejector in order to reduce the steam consumption, but they are not necessary if the heat in the steam used does not raise the temperature of the feed water to too high a degree.

Feed Pumps

Merchant ships are using vertical, simplex, double-acting type feed pumps, independent of the main engine. In naval practice the same type is used for auxiliary feed purposes, but for the main feed turbine driven centrifugal pumps are being installed on large vessels.

In naval service the centrifugal pump, either steam or motor driven, is coming into use wherever this type of pump is practicable. The Bureau of Steam Engineering, Navy Department, has given a great deal of careful study

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to the question of speed control for turbine-driven auxiliaries supplemented by actual tests and experiments on board vessels of the fleet, with the result that satisfactory governing devices have been selected.

In the merchant service, pumps, except main air, feed and circulating, are nsually of the horizontal, duplex, double-acting type, but even here the centrifugal turbine or motor-driven pump is coming into use and is found in not a few new turbine-driven ships.

On motorships, motor-driven pumps, and in fact motor-driven auxiliaries of all types are the rule.

Forced Draft Blowers

The turbine-driven blower is the standard for naval vessels when forced draft is installed. This has replaced the motor-driven blower principally on account of its greater range of and better elasticity of speed control, and the fact that it is independent of the ship's generators.

Merchant ship blowers are usually driven by reciprocating engines; there is a tendency, however, to install motor drive.

Feed Water Heaters

Feed-water heaters are now always installed on naval vessels. The type is the closed heater on the discharge side of feed pumps. Straight, "U" and coiled-tube types are used. The specifications have recently been changed to provide for a capacity 25 percent greater than is necessary to obtain the required feed temperature at full power and drain of such size as to handle twice the condensed steam expected. For feed-heating reasons, the pressure on the auxiliary exhaust system is carried at a standard of 10 pounds gage, and steam not condensed by the feed heaters is spilled into the main engines, with an emergency relief to condenser.

Feed heaters are being installed in the most up-to-date merchant vessels, the installation being similar to naval practice except that the pressure carried on the auxiliary exhaust system is 5 instead of 10 pounds gage.

Evaporating (Distilling) Plants

These have recently received a great deal of attention and improvement in the Navy. The low capacity (25 gallons per day per square foot heating surface), horizontal straight-tube type has been abandoned for the high capacity per square foot heating surface, vertical coiled or "U" tube types. The latter type of evaporator has been developed to a remarkable degree and capacities of 120 gallons per square foot heating surface per day have been made. Naval practice now limits this to 60 gallons per day per square foot heating surface, except on destroyers, where as high a figure as 80 is allowed.

On naval vessels it is usual to install evaporators for operating on live steam using the double-effect system. Latest installations allow for the use of auxiliary exhaust in coils, the evaporators being operated single effect and an air pump being provided for maintaining about 20 inches of vacuum on the distilling condensers. This has proved to be an installation producing great economy.

Low Pressure Distilling Plants

It is not customary to use more than double-effect operation, but an exception to this is the interesting installation in the battleships *Tennessee* and *California* to be commissioned in the near future. With the exception of the installation in the *Dixie* these are the only all low pressure distilling plants in the Navy. Six evaporators are installed and piped up so that they may be operated in single, double, triple, quadruple or sextuple effect. Live steam may be admitted to first effects and auxiliary exhaust may be admitted to first effects for single effect operation or to the second effect in multiple effect operation.

The daily capacity of naval distilling plants has been materially increased, destroyers from 5,400 gallons to 10,500 gallons in latest boats and on battleships from 25,000 gallons on the *Pennsylvania* class to 50,000 gallons on the 49-54 class (60,000 shaft horsepower), and 70,000 gallons on battle cruisers 1 to 6 (180,000 shaft horsepower). An allowance of 10 gallons per man per day is considered with the Navy a liberal allowance for all purposes except for engineering department, and in the engineering department on large vessls an approximate figure for making up feed expenditure is 1,800 at anchor, and 4,200 under way at 12 knots (varying trom this with the power required). These are not design figures.

Practically all merchant ships recently built have evaporating plants of considerable capacity installed. The capacity is now such that the vessel may, if desired, distill all of the water for both deck and engineering purposes.

Refrigerating Plant

On merchant ships built during the past few years, a refrigerating plant of ample capacity is always found in almost all cases. On cargo ships this is about two tons per 24 hours. Ammonia compression, ethyl chloride, CO_2 and SO_2 systems are the rule with preference for SO_2 in the Shipping Board vessels. Steam drive is being displaced by motor drive. The dense air system has until recently held the field in the Navy. CO_2 systems are now installed on practically all new ships, except destroyers where ethyl chloride and SO_2 systems are found with a few of the CO_2 type. Naval refrigerating apparatus of whatever type is turning to motor drive especially for small-size systems of two tons and under.

Electical Plant

Aboard ship electricity is being put to more and more purposes and the electrical plant is a most important part of the installation. The geared turbo-driven generator is the naval practice, while the reciprocating steam engine-driven generator is found in most common use on steam merchant vessels, with turbo drive on a few. Ships with internal combustion engines for main propulsion commonly use the same type of engine for generators.

The sets are now installed in duplicate on merchant ships, this having always been the naval practice. It is believed that the introduction by the Navy of interior communication on commercial vessels during the war will have a lasting effect in that the need of the telephone, call bell, and electrical indicator for various purposes will be felt by merchant ship captains. The electric motor-driven pump which is being taken up on these vessels will also mean an extension of the electrical plant. Radio installations on merchant ships are now looked upon as a necessity.

Conclusion

In summing up the situation, one need not be a born optimist to feel that tremendous strides have been made in the general improvement of engineering at sea, and that future developments as indicated by conditions today will be most interesting.

The ninth annual banquet of the Delaware River Branch of the American Society of Marine Draftsmen was held at the Hotel Adelphia, Philadelphia, Pa., on February 27, with about 350 members and guests present. A. H. Haag, president of the society, presided.

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Machining and Erecting Marine Engines

BY WILLIAM WYLDE* AND R. M. SHERMAN†

Considering the long periods of constant running, and, at times, the extraordinary conditions to be met and overcome, it is of prime importance that the marine engine should be designed and built by, or under the strict supervision of, men trained for that purpose. Each unit should be machined accurately, and, when assembled, should have such clearances for working fits as have proved by actual experience to give the minimum friction and the maximum service. This article tells how such work is carried out in the shops of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va.

THE engine, the construction of which is described in this article, is of the vertical, quadruple expansion type with cylinders 24 inches, 35 inches, 51 inches, and 75 inches in diameter, by 51-inch stroke, fitted with Stephenson link-valve gear and designed for 2,600 indicated horsepower, at 70 revolutions per minute. The working boiler pressure is 220 pounds gage. The high pressure and the first intermediate-pressure valves are of the piston type, and the second intermediate, and the low-pressure valves are of the double-ported slide type. Balance cylinders are fitted for the valves of the first and second intermediate-pressure and the low-pressure cylinders. An Aspinall marine governor is fitted.

The crank shaft is of the built-up type in four interchangeable sections. The bedplate is cast iron, of the box-girder type, in four sections. The cylinders are cast iron, the two intermediate-pressure and the low-pressure cylinders are bolted together, and the high-pressure cylinder is secured to the others by means of rugged tie rods. Cast-iron liners are fitted in all the cylinders except the low pressure. The high-pressure and the first intermediate-pressure pistons are cast iron and the second intermediate pressure, and the low pressure are cast steel.

The arrangement of cylinders, beginning at the forward end, is high pressure, low pressure, second intermediate pressure and first intermediate pressure. The columns are cast iron of box section with ahead and backing guides bolted on each. Receiver pipes from the high pressure to the first intermediate-pressure cylinders are of copper and the receivers for the other cylinders are integral with the cylinders. The piston rings overrun ¼ inch at the top and 0 inch at the bottom.

The operating gear is on the starboard side of the engine. A small double-cylinder turning engine is bolted to the back housing of the first intermediate-pressure cylinder. A single-cylinder reversing engine is bolted to the back housing of the second intermediate-pressure cylinder. An efficient lubricating system is connected to all bearings, and water service is led to the main bearings.

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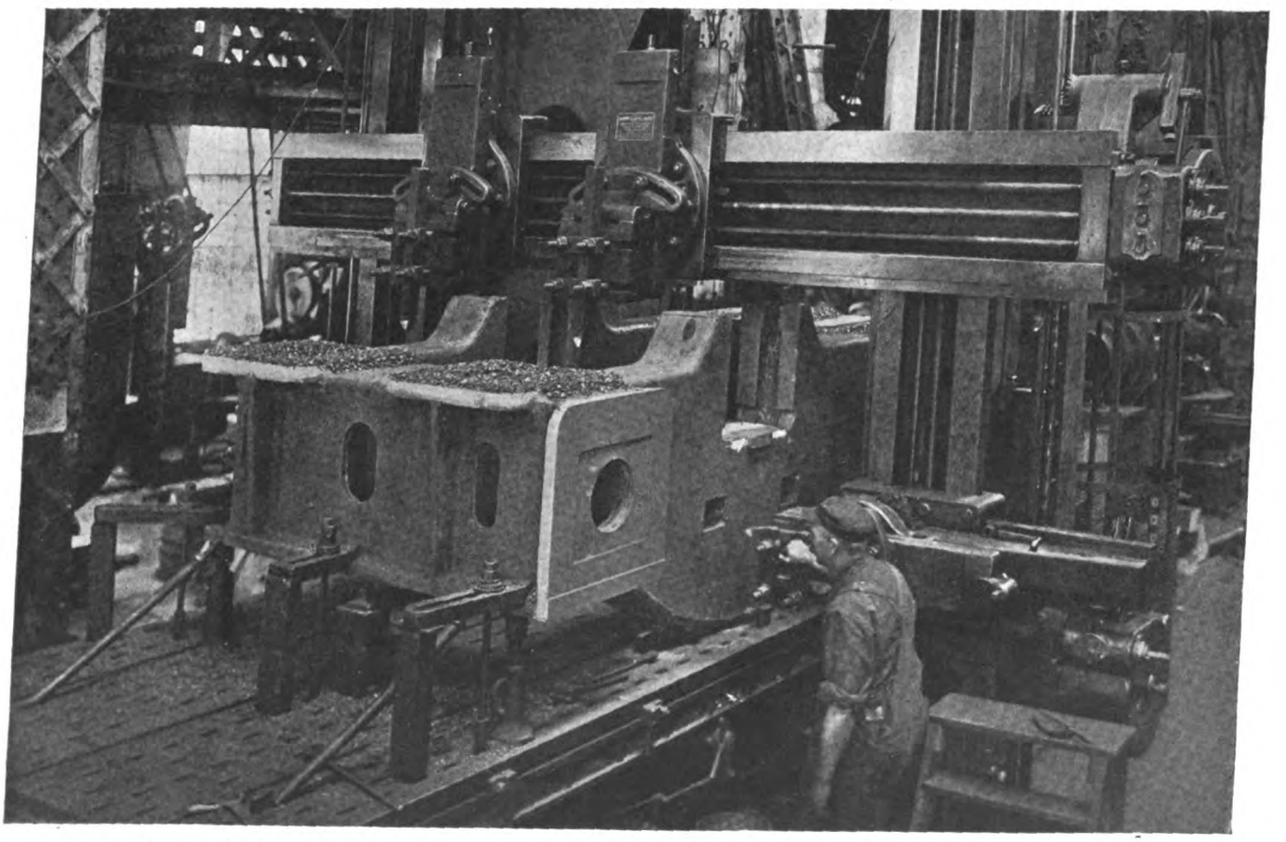

Fig. 1.—One Section of Bedplate Set Up on Planer Where the Joints and Housing Facings Are Planed Simultaneously

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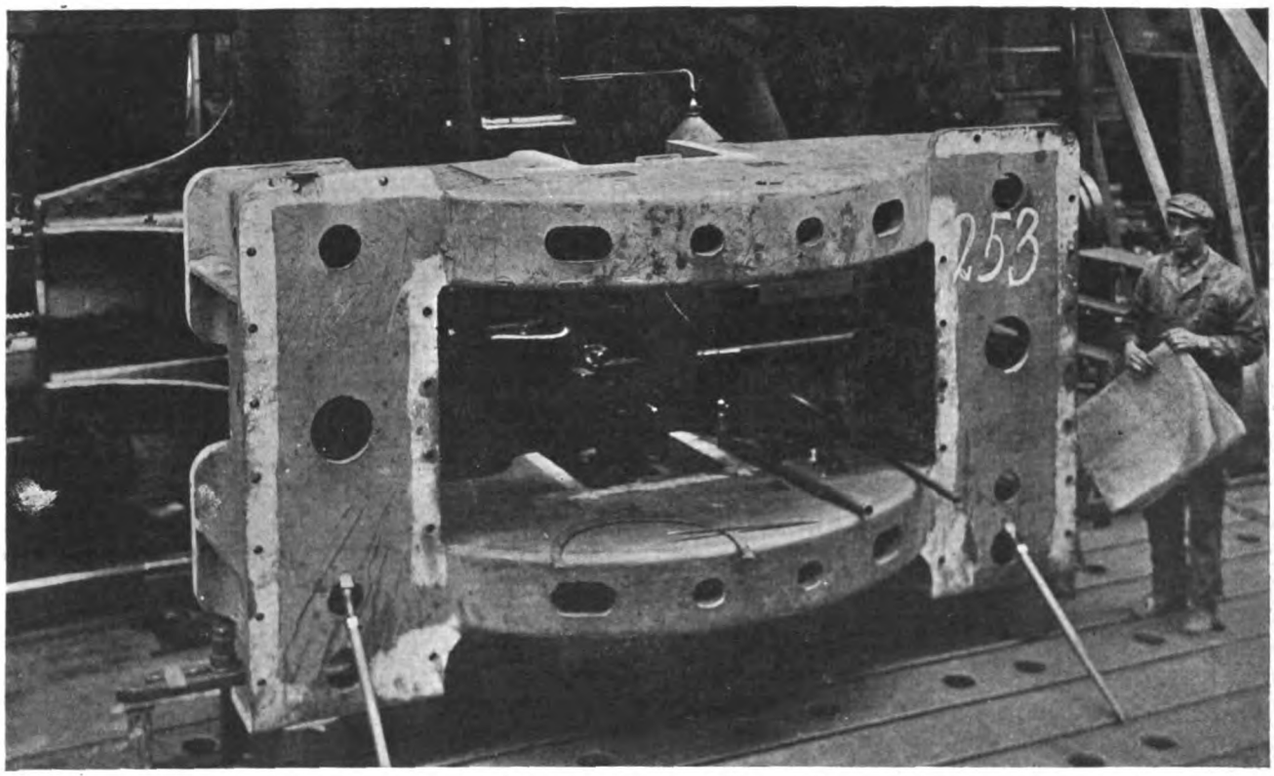

Fig. 2.—Section of Bedplate Set Up on Wall Planer Where the Recesses for the Main Bearings Are Machined

The thrust bearing is of the horseshoe type, with ten collars and fitted with a steady bearing at each end.

BEDPLATE

The bedplate is the basic unit of a marine engine, and it is of prime importance that both material and workmanship be fundamentally right.

When the width and length of a bedplate exceed the capacity of a planer, it then becomes necessary to machine it in sections as illustrated. The first operation is shown in Fig. 1, where a section is being machined. In this machining it is important that the joints are planed square with the column or housing facings, that the faces for the housings are machined so that the contour of the bedplate will be uniform when assembled; that all flange thicknesses and the length over all, and from center to center of crank pits, be kept to design.

Fig. 2 illustrates the method of machining the recesses for the main bearings on a wall planer. It is most important to set the section so that when it is planed the joints will be square with the sides of the main bearing recesses and the facings for the housings parallel with the bottom of the main bearing recesses. Having the section thus set, the width of the recess is accurately machined to a pin gage, and the distance from the housing facing to the bottom of main bearing recess made to a

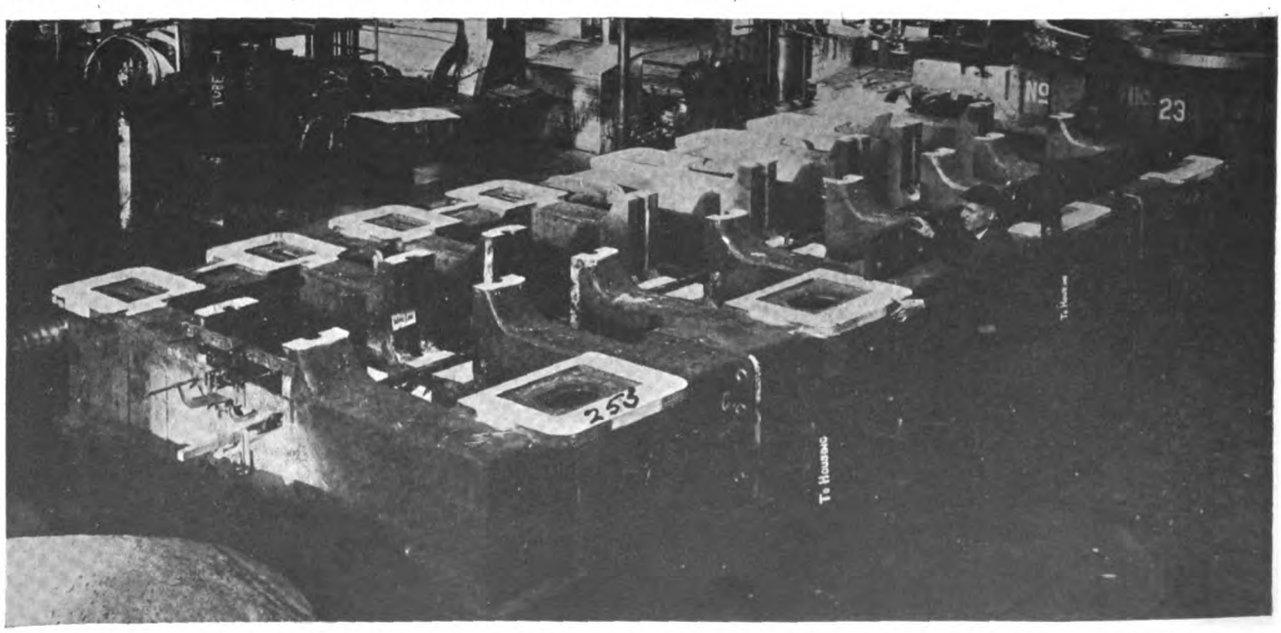

Fig. 3.—Four Sections (the Complete Bedplate) Clamped Together Are Lined Up and Then Laid Out for Drilling, Etc.

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block gage. When this operation is complete the sections are taken to the surface table where the machine work is checked, after which holes for holding down bolts, main bearings, and one flange of each joint are laid out for drilling.

After the first drilling operation is complete, the sections are assembled as shown in Fig. 3, and the following operations performed: the housing facings are accurately set on the same plane by the use of a long straight edge and a sensitive spirit level; a fine steel-wire line is made fast at each end of the bedplate, and drawn taut through the center of the main bearing recesses, and in the same plane with the facings for the housings, after which the sections are shifted until the sides of the main bearing recesses are central with the wire line and in alinement, and spots for reassembling chipped, filed and scraped on each joint; centerlines parallel to the wire line are drawn on the housing facings; centerlines at right angles to the wire line and through the center of the crank pits are drawn on the housing facings; templates are then placed on the housing facings so the centerlines on the templates coincide with the centerlines on the facings, and from these templates holes for drilling are scribed off. Having previously mentioned that one joint flange at each section was laid out and drilled, the others are now scribed off and the bedplate is taken apart for the final drilling. After the final drilling, the bedplate is sent to the erecting shop for general assembling.

Housings or Columns

When the length of housings, or columns, exceeds the width of the planer, the faces of the top and bottom flanges must be milled or faced on some other machine. The housing shown in the illustration is too long for the planer, and in this case a wall planer is used. The same method, however, can be applied when machining housings on either a milling machine or a rotary planer. The first operation, however, is to put them on an ordinary planer and to set them carefully, so that when the faces for the guides are machined and the upper and lower flanges planed at right angles to the guide faces, the axes of the housings will have the correct inclination. Having thus planed the guide face, the housing is taken to the surface table and laid out for length. The bottom flange is next planed square with the guide face, after which the housing is set in a jig (see Fig. 4), where it is planed to exact length.

From the wall planer, it is again taken to the surface table, where the machine work is tested for accuracy. If found within the tolerance limit of .004 inch, it is laid out in the following manner:

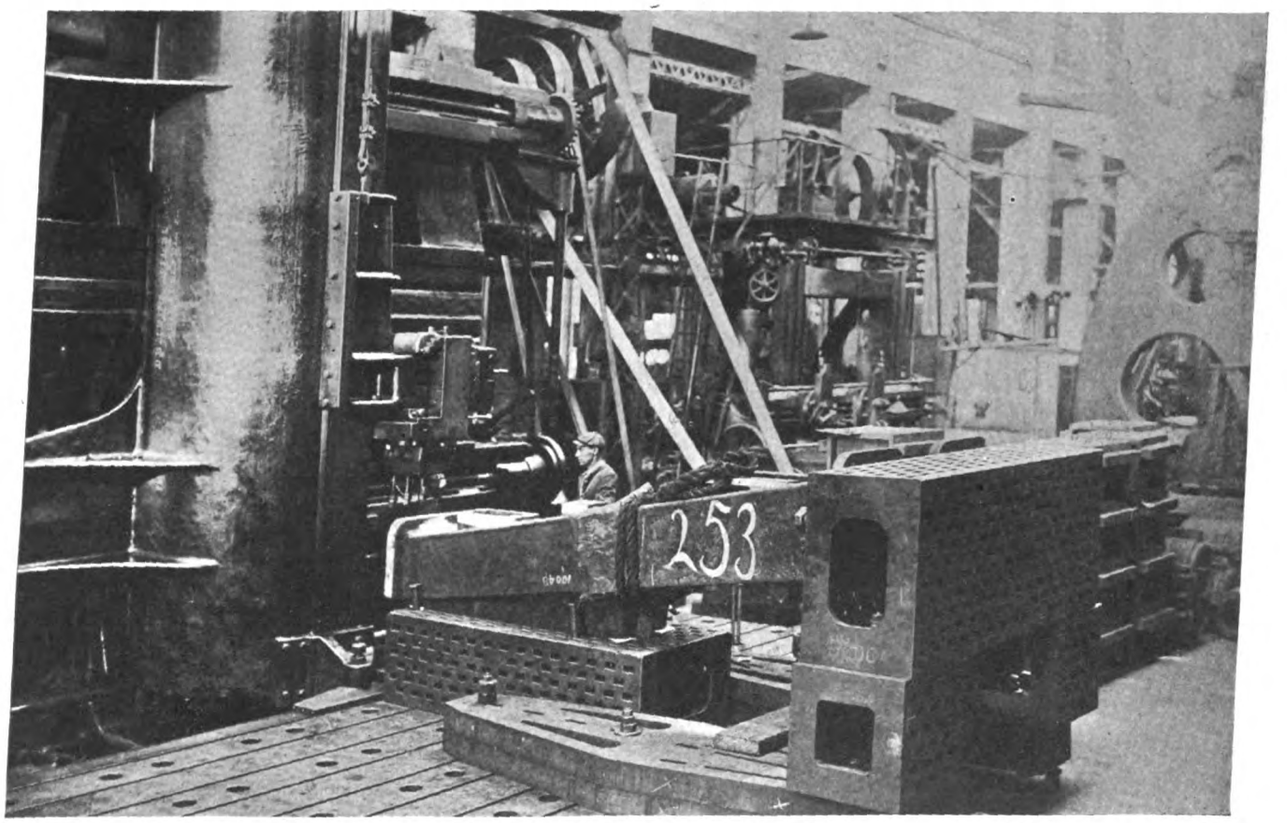

Fig. 4.—Method of Planing Housings to Exact Length on a Wall Planer

With the guide face resting on, or parallel to, the surface table, centerlines are drawn on both the top and bottom flanges, and extended across the edges. The housing is then turned on its side and set so that the centerlines drawn across the flanges are square with the surface table; then other centerlines are drawn at right angles to the first ones, intersecting at the axis of the housing, agreeing with the centerline drawn on the cylinder feet and the bedplate facings, respectively. The templates, which were used in laying out the housing facings on the bedplate and on the feet of the cylinders, are now applied to their corresponding flanges on the housings, and the holes laid out for drilling.

The guide plates which have been laid out and drilled are now clamped to the housings, and the holes for bolting them in place are scribed off on the housings. Before taking the guide plates off they are plainly marked

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for their respective places. The housings are next drilled, tapped, spotfaced and reamed, after which the guide plates are bolted on. The housings are then ready to be erected in place.

CYLINDERS

The cylinders of an engine are among the most prominent parts, and when in process of machining they should be so handled that every detail of the work is executed with care. When first received from the foundry they are pickled in a solution of one part sulphuric acid to four parts water to loosen the sand and scale, then placed on a surface table, inspected and carefully laid out for machining. The bore must be smooth, accurate and parallel, and the length of the wearing surface such that when the piston has the correct amount of clearance, top and bottom, the rings will slightly overrun to prevent wearing

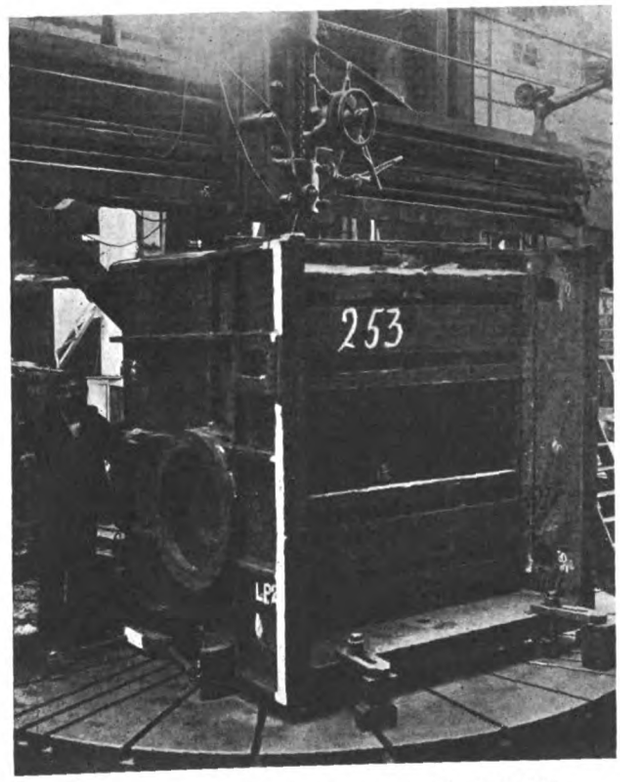

Fig. 5.—Boring a Cylinder on a Large Vertical Mill

shoulders. Marine-engine cylinders should be bored in their working position vertically, or otherwise as the case may be, as shown in Fig. 5.

The cylinder is first set true to the preliminary layout, clamped firmly to the table and bored, using two roughing tools simultaneously, and taking the maximum cuts and speeds possible without producing prominent chatter marks. For the second cut, one roughing tool is used, which leaves the bore cylindrical and uniform for the finishing tool. The third or finishing cut is taken with a tool approximately two inches wide, using about 1-inch feed, and running at a cutting speed of about sixteen feet per minute. This gives a smooth, straight cut, free from chatter marks.

After boring and facing, the cylinder is taken to the planer, where the face of the joint is planed parallel to the bore, and the distance from the center of the cylinder to the face of joint is kept accurately to the given dimensions. A cast-iron mandrel about four feet longer than the cylinder, and turned six inches in diameter to gage size is fixed rigidly and accurately in the center of the bore as shown in Fig. 6. The ends of the cylinder are lowered

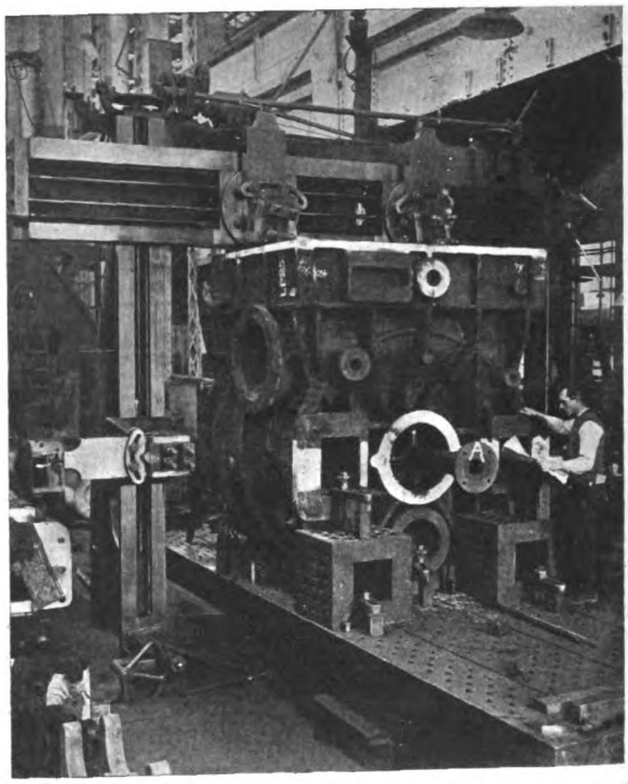

Fig. 6.—Planing a Cylinder Accurately Will Obviate Trouble When Lining Up

or raised, as the case may require, until the distance from each end of the mandrel to the crossrail caliper is the same. The same principle is then applied from the side head to the mandrel. Having the cylinder set, the dimensions for machining are taken from the circumference of the mandrel, remembering that one-half the diameter of the mandrel must be considered when measuring. By turning the top of the cylinder downwards, with the finished face on or parallel to the planer table it is now in a position where its feet can be planed at right angles to the bore by using the crossrail head. The next operation is to

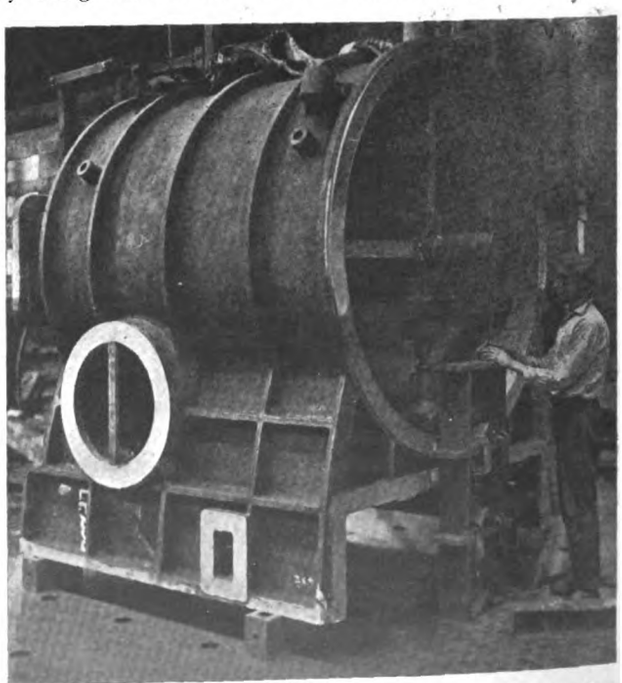

Fig. 7.—Carefully Checking All Machine Work and Laying Out for Drilling and Assembling

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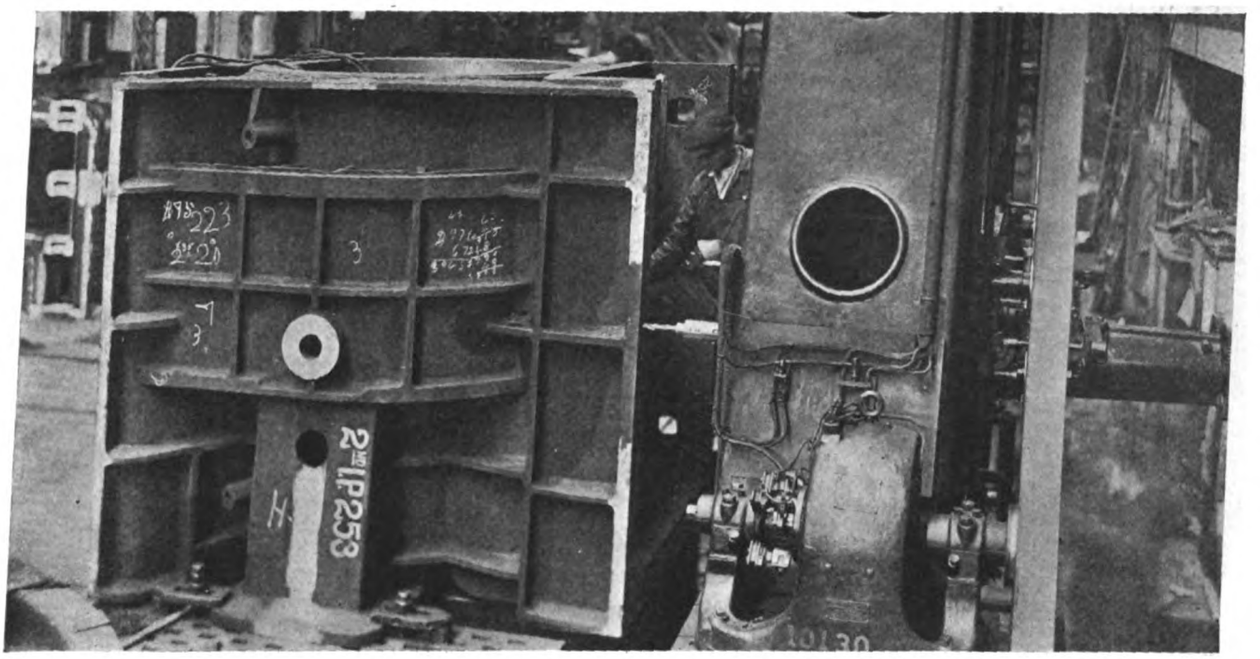

Fig. 8.—Drilling Holes in Cylinder on Horizontal Drill Press

check carefully all machine work and layout for drilling.

The method of laying out cylinders differs according to their type, but the essential features of the process are the same in all cases. The cylinder chosen for illustration is shown in Fig. 7, and is a low-pressure cylinder of the double-ported slide-valve type, 75-inch bore by 51-inch stroke. The work of laying out is done in two operations, as follows:

First: The cylinder is placed on parallel blocks on the surface table with the joint down and with a cast-iron mandrel, as previously described, set central with its bore. By the use of surface gage, straight edge, and a large square, centerlines are drawn fore and aft, and athwartship. Templates for laying out the feet are then set, and the machining of the joint checked from the mandrel. After all the accessible surfaces are laid out and the machine work checked the mandrel is removed, and the length of wearing surface, counterbore and clearances are measured for accuracy.

Second: The cylinder is then placed on its feet, and from the face of the feet as a base the remainder of the spacing and checking is done.

After the layout is finished the cylinder is taken to a horizontal drill press (see Fig. 8), where all holes are drilled, spotfaced, tapped and reamed according to the stamped or other marked instructions put on by the layer-out. After drilling, all internal parts such as steam passages, etc., are thoroughly cleaned and fins removed; the valve liners, or false faces, and other fittings are assembled, some permanently and others temporarily, to insure the accuracy of workmanship.

Crank Shaft

When all the auxiliary parts have been fitted and proved correct, the cylinder is subjected to a hydrostatic test of about double its working steam pressure. While under this pressure, every part is carefully examined to see that the casting is perfectly sound and free from hidden imperfections. If no defects develop, the water is drained out and the cylinder is ready to take its place in the final assembly of the engine.

The crank shaft of a marine engine, being one of the most important parts, should, to insure the utmost security in service, embody only the highest grade of material and of mechanical excellence.

After the shafts, pins and webs are forged and annealed, two coupons or test pieces are taken from each forging for tensile and bending tests. If the tests meet the requirements, the pins and shafts are rough turned to within ¼ inch of their finished sizes, to ascertain that the metal is free from imperfections. The webs are laid out and holes for the shafts and pins cut with an acetylene torch, leaving them about 2 inches smaller in diameter than the desired bore.

The webs are again annealed and planed to the re-

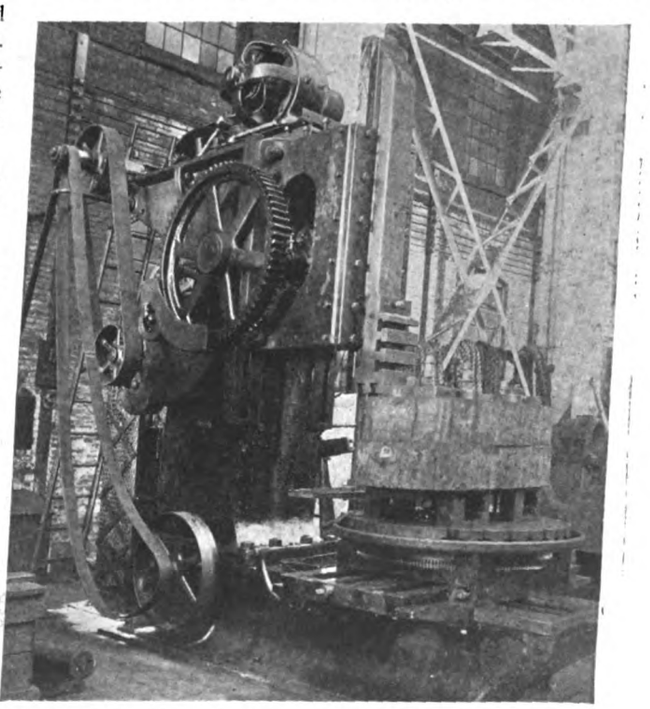

Fig. 9.—Slotting the Ends and Sides of Crank Webs on a 42-Inch Slotter

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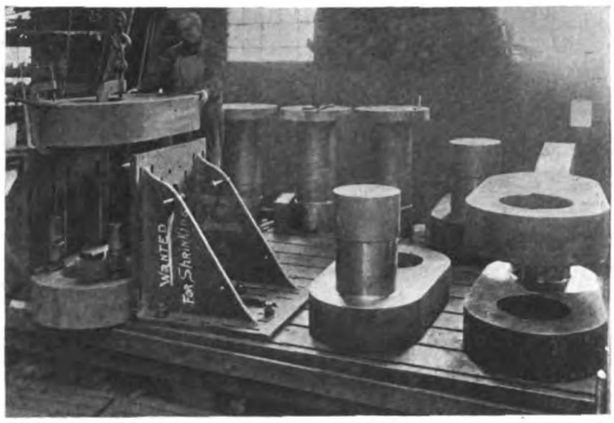

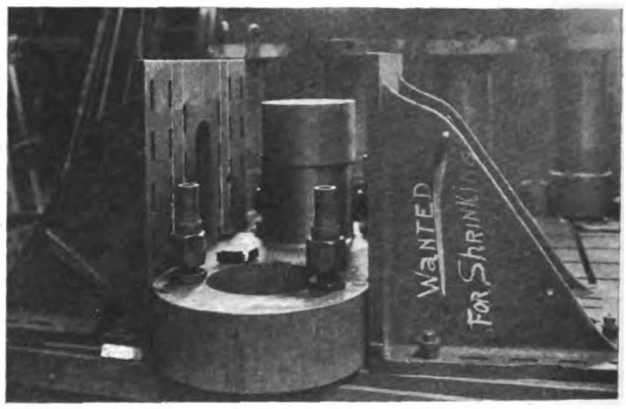

Figs. 10 and 11.—Shrinking Crank Webs Accurately on Pins and Holding Bore for Shafting in Perfect Alinement

quired thickness, laid out for machining, clamped together in pairs, and put on a vertical mill, where the holes for shafts and pins are bored smoothly and accurately to a pin gage. The keyways are cut on a keyseater, after which the clamps are carefully changed to the inside of the bore, so that the edges of the webs can be machined parallel to the bore. The ends and sides are machined to finished size on a slotter (see Fig. 9). After being completely machined the webs are marked high pressure fore and high pressure aft, etc., separated and all outside corners rounded.

The pins are turned for shrinkage in the webs, and the journals are ground to snap-gage size for connecting-rod bearings. An allowance of .001 inch to the inch diameter for a shrinkage fit has proved entirely satisfactory for crank shafts and pins.

The end pieces of the crank shaft are rough-turned only, except the fit for shrinking and the adjacent end, which are finished. On the sections which couple the high pressure and low pressure, and the first and second intermediate pressure together, only the faces inside of flanges and the fillets of the coupling are finished. These shaft ends are then laid out, keyseated, drilled, reamed and fitted with coupling bolts. After this they are put in a lathe and turned for shrinkage fits, faced to correct length, and spots turned on each section close to the coupling fillet for future checking after the parts are assembled.

It might be well to state that with the use of a little "shop trig," the laying out of the eccentric keyways in a crankshaft may be done easily, and with a high degree of accuracy. After completing the foregoing operations and preparatory to assembling, the work is checked and a pilot key tried in all keyways.

The first step in assembling is to heat one web of each crank and to shrink a pin in place. Two accurate angle plates are set on a heavy cast-iron plate, and made fast to suit the width of the webs (see Figs. 10 and 11). A web having a pin shrunk in is then placed on the plate between the angle plates with the pin up, leaving a definite amount of clearance on each side to allow for the other web when expanded. On the face of the lower web, and close to the outer edges, four distance pieces, with length equal the distance between the webs, are arranged. Then the expanded web is placed, and the axis of the bores for the shafting is kept true to alinement, while the webs are held the prescribed distance apart. The application of cooling water must be uniform to obtain uniform contraction of metal.

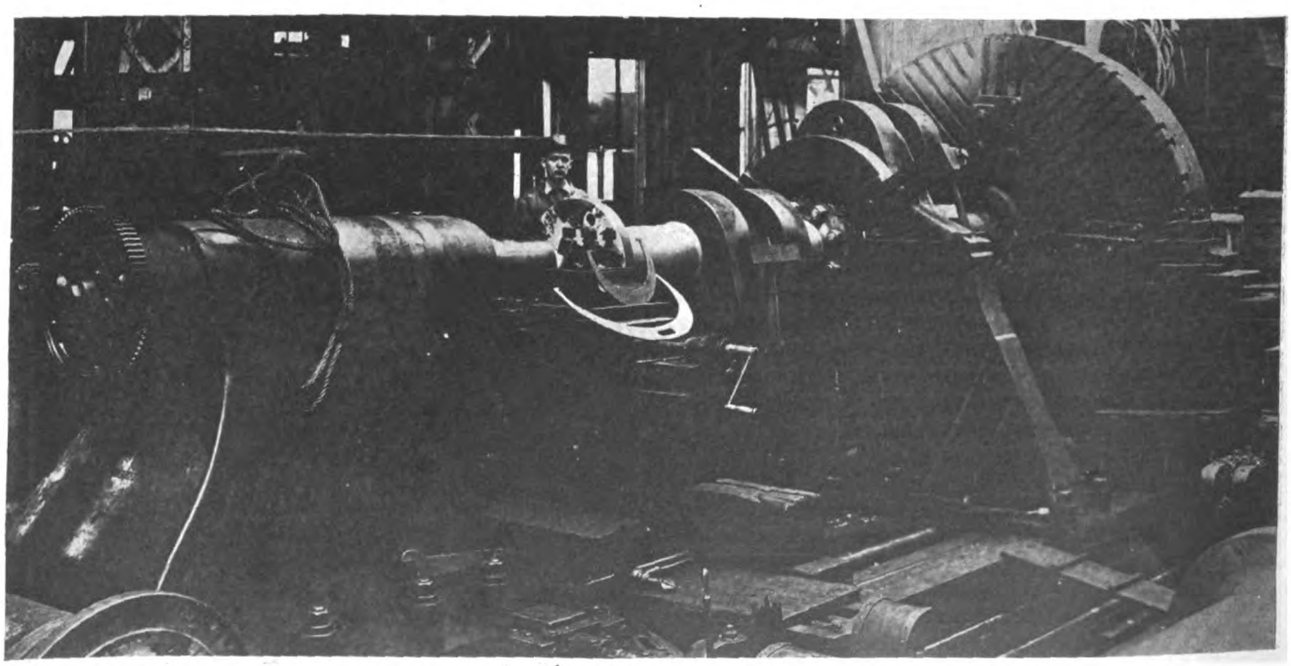

Fig. 12.—Two Sections of Crank Shaft Assembled and Set Up in Lathe Where It Is Turned to Exact Gage Sizes

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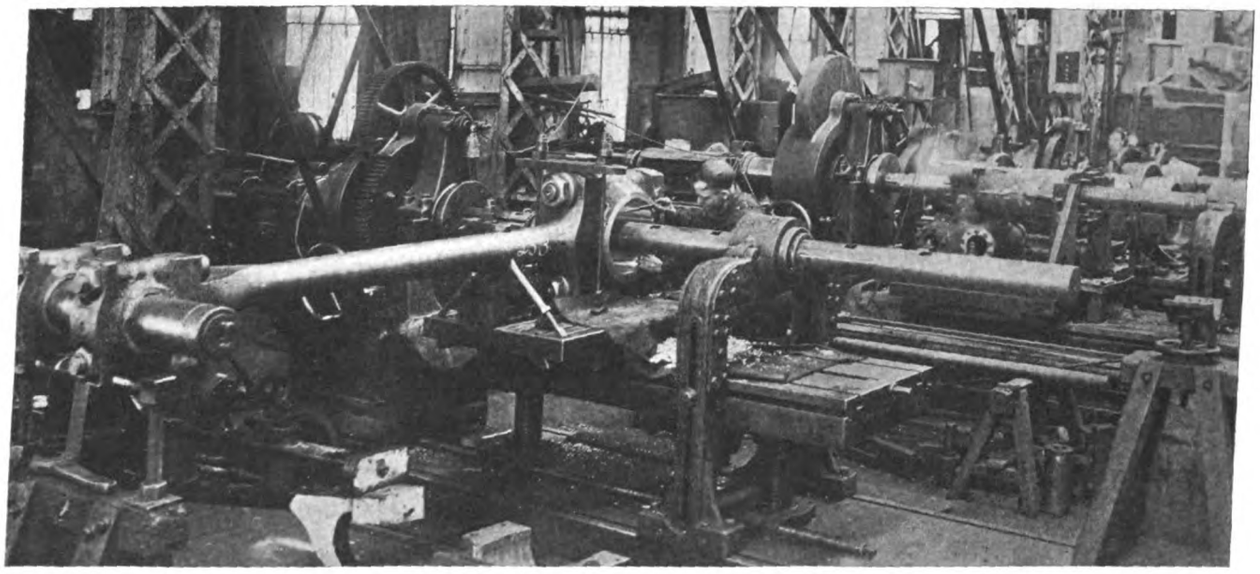

Fig. 13.—Connecting Rod Set Up on a Horizontal Boring Mill Where the Upper and Lower Bearings Are Bored in Perfect Alinement

After the webs are cooled, one web is heated for the shaft end, and a section shrunk in place. To keep the keyway true, and the end of the shaft even with the inside of the web, a pilot key is used and a heavy parallel, extending across the underside of the web, held firmly in place by small jack screws made for such purposes. After the shaft is shrunk in place, the key is fitted and driven in with a ram.

The same method is used for the opposite web, except the key has to be forced in with a jack, as there is no room for a ram. In using a jack to force the key in place, the open end of the webs is supported by heavy clamps to prevent any distortion.

After the shrinking operation is complete, and all keys are fitted and forced into place, the sections are assembled and set to lines previously put on by the layerout. The holes are then reamed and coupling bolts fitted. Distance pieces are fitted between the webs so that when the complete shaft is placed in the centers of the lathe it will be rigid (see Fig. 12).

Having the shaft in the lathe centers with a support near its center, but allowing it freedom to show its true character on the dials of micrometer indicators placed at or near each end, and at or near the center on the spots previously turned for this purpose, will beyond question reveal the class of workmanship previously performed when machining, shrinking and assembling. Should the shaft not run true, the centers must be drawn so that the inaccuracies will be equalized in the shaft, and at the same time so that the pins will be absolutely parallel to the shaft when finished.

After the shaft is centered to meet these conditions, the couplings and shaft are turned smoothly and accurately to snap gage. All journals are first turned true and smooth about .003 inch large with a dry cut, after which a water cut is taken, which leaves them smooth and polished. The crankshaft is then taken to the erecting shop, where the eccentric keys are fitted and the eccentrics clamped in their places.

Connecting Rods

As the connecting rod is subjected to various and severe stresses, it is very important that the machining, assembling, and final boring be removed entirely from the domain of chance and reduced to a practical certainty. Fig. 13 shows an assembled rod receiving its final boring. After the body of the rod has been turned, the greatest care should be taken to see that the ends are faced off true, and to the exact length, before it is removed from the lathe. The rod is then laid out, drilled, assembled and laid off for the final boring of the bearing boxes.

The crosshead end bearings are bored accurately to size and parallel to the faces of the upper end. A cast-iron mandrel about two feet longer than the upper end is made and snugly fitted in these bearings. When setting the rod for boring the crank and bearing, the mandrel is kept in the crosshead end bearings and, with a sensitive V-shape spirit level, the mandrel is set on the exact horizontal plane with the boring bar. It is then set parallel to the bar by use of the caliper tram shown. When thus set and bored, the bearings in the upper and lower ends are parallel.

Radius Links

Radius links are machined in various ways, according to the shop equipment available. The process described gives entire satisfaction and reduces the fitting work to a minimum.

Temporary holes are located, drilled and tapped in the link bars, for holding them on the planer table while

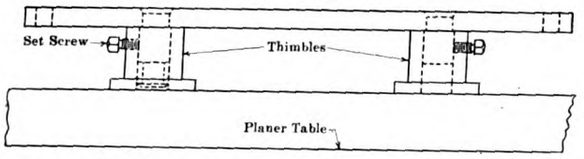

Fig. 14.—Method of Holding Link Bars on Planer Table When Taking the Last Finishing Cut

machining. (These holes are so located that when holes for pins are bored and reamed they are machined out.) Either four or eight link bars are fixed on the planer table at one time, where they are rough machined on both sides; then one side is finished smooth and true, leaving 1/32 of an inch to come off the opposite side after the pins are riveted in place.

After the first planing operation they are laid out,

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clamped together in pairs, drilled, bored, reamed, and countersunk for pins. They are then marked and separated, and the pins pressed into place and riveted, after which the face of the link bar is tested to ascertain if it has been distorted, and the pins to see if they are square with the face of link bar. After being proved correct, they are placed on the planer (see Fig. 14) with the pins down and in thimbles, where the unfinished sides are machined smooth and the link bars made to thickness.

After experimenting with various cutting compounds to obtain a smooth, accurate finish on this work, spirits of turpentine and kerosene (paraffin) oil mixed in equal quantities and applied with a brush was found to give the best results.

Link Blocks

Link blocks are first subjected to a preliminary layout, then turned and faced for width and length. After this

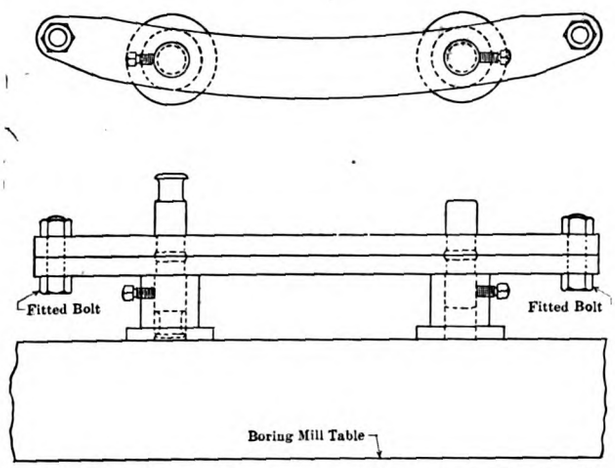

Fig. 15.—One Set of Link Bars on Vertical Boring Mill Table. Usually Four or Six Sets Are Turned and Bored at One Time

they are arranged on the planer in a double row, so that two tools can be used simultaneously for machining. When one end is finished they are turned over, with their faces on the table, and planed sides against heavy parallels or straight-edges set true to the travel of the machine. This brings the rows of blocks in line with very little effort, and should one or more chance to shift, they would be easily detected. After the planer work is finished, brass gibs or shoes are fitted, and secured in place by tap bolts. The blocks are then laid out and placed on a vertical boring mill, where one end is bored to the correct diameter and the width to gage.

Before boring the opposite end, cast-iron pieces about an inch or more longer than the link blocks are clamped to the table, and turned the same diameter as the link bar. The link blocks are then put on the table with the finished end down, and with the gibs hard up against the cast-iron pieces, are turned to the correct diameter and the width to gage.

They are then moved from the boring mill to the fitting department, where the oil ways are cut and the link blocks fitted to the links.

The link bars and link blocks are machined to gage size (or metal to metal) so that when the rough spots are removed and the link bars polished an exact working fit is obtained. After planing, the links are clamped together in pairs to previous markings. Fitted bolts or snug-fitting bushings are used in the reamed holes in each end; these hold the pins in both link bars in positive alinement. One side is then laid out for machining, after which the ends and the portion up to the radius is slotted.

From the slotter they are taken to a large vertical boring mill (see Fig. 15), where they are placed on the table in sets of from three to eight. They are mounted in thimbles as in the last planing operation, and are set true to layout. The pins are then tried, to insure that they will be true and central when the turning is finished. The links are bored to the correct diameter, and width, measuring the width with a snap gage. They are next taken apart and any rough parts and sharp corners which may have been left in machining are filed and polished, after which they are ready for assembling and for fitting the link blocks.

Thrust Shaft

Fig. 16 illustrates the process of turning a thrust shaft. When roughing, four tools are used simultaneously, using a good cutting speed and heavy feed.

After the shaft is rough turned all over, the collars and recesses are finished to gage with a very smooth dry cut. The other surfaces are also finished dry except the pillow block journals, which are first finished dry approximately .003-inch large and then turned to snap-gage size with a water cut. After the shaft is turned the collars are polished to obtain the best finish possible for the thrust-shoe bearings. The shaft is then laid out to

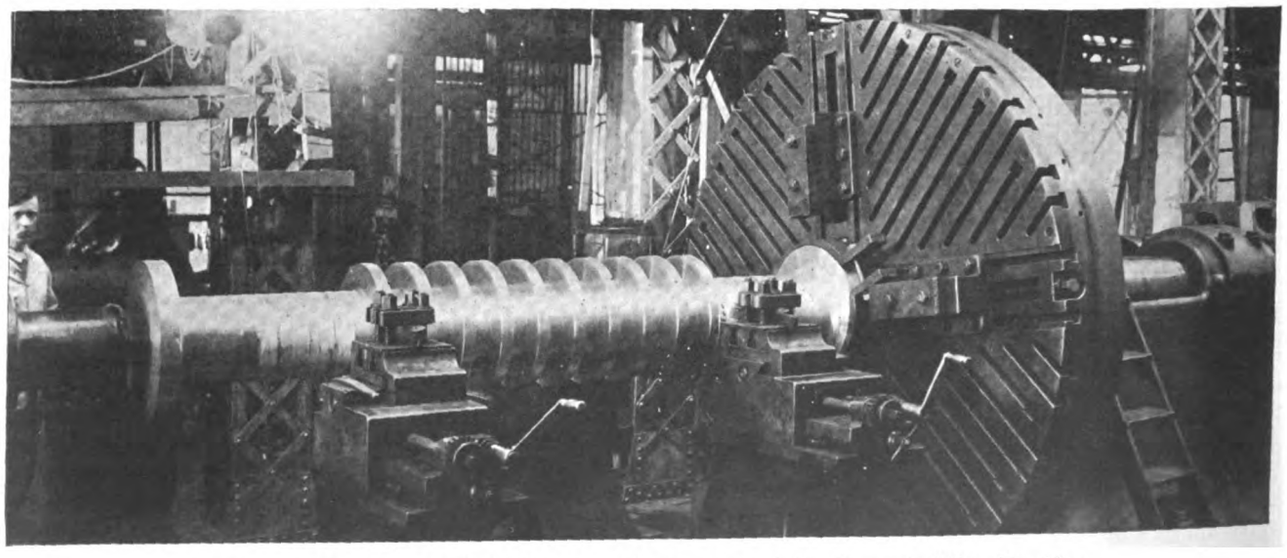

Fig. 16.—Turning a Thrust Shaft Where Four Tools Are Used Simultaneously When Roughing

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template, drilled, spot-faced, and reamed to suit the adjacent couplings.

Line Shafts

A dry, smooth finishing cut is taken over all-line shafts, except the steady bearing journals, which are finished to size with a water cut and polished. The couplings are faced true, and before reaming are tested in the following manner: a thin coating of marking mixture, such as red lead thinned with lard oil, is rubbed over the face of one coupling, the other coupling is then drawn hard up against it and separated; if the surfaces are covered with bearing marks from the periphery to at least three inches inside the bolt holes, they are again carefully assembled so as to obtain absolute concentricity, and the holes reamed and coupling bolts fitted. Both the couplings and the bolts are clearly marked for their positions. This being done, the shafting is taken apart and painted all over, except the journals and coupling faces (which are coated with oil), and sent out for installation in the ship.

Thrust Shoes

The method of handling thrust shoes from the rough casting to the finished product is as follows:

They are laid out, drilled and tapped for water circulation, thoroughly cleaned inside and out, and all fins and other obstructions removed. Each shoe is then subjected to a hydrostatic pressure of 30 pounds per square inch, to prove its fitness for use. The sound shoes are babbitted and machined .010 inch less than the recess in shaft, to allow for working clearance. For forced lubrication, the clearance is less, usually about .005 inch. After machining for thickness the shoes are clamped together in sets for boring and planing, the end shoe having been laid off for this purpose. Fig. 17 shows a set of shoes on the planer.

After the boring mill and planer work is finished the shoes are laid out, drilled and spotfaced. They are then taken apart, and the oil grooves are cut and all the equipment fitted. After correctly locating the thrust shaft in the bearing, the thrust shoes are clamped in their places and tested for working clearances.

Erecting a Marine Engine

A marine engine should in all cases be erected as completely and as perfectly as possible before it leaves the shop, as the entire equipment of the shop is available, and the work can be done there to better advantage than on shipboard.

It is very important that the foundation should be rigid, so that there will be no danger of the bedplate springing under the heavy weight of the various units placed upon it.

Bedplate

The first step in assembling is to place the bedplate on the foundation and set the sections accurately to the spots chipped, filed and scraped at each joint, and to bolt them together. The bedplate is then leveled with a very sensitive and accurate spirit level, placed on straight edges. This requires considerable care, as the operation of leveling first one side and then cross-leveling to the other is repeated several times until no further error can be detected. The leveling wedges and shims must be so arranged as to take the ultimate weight without disturbing in any way the true condition obtained. After the bedplate is level and accurately in line and resting on a rigid foundation, the holes are reamed and bolts fitted at each joint.

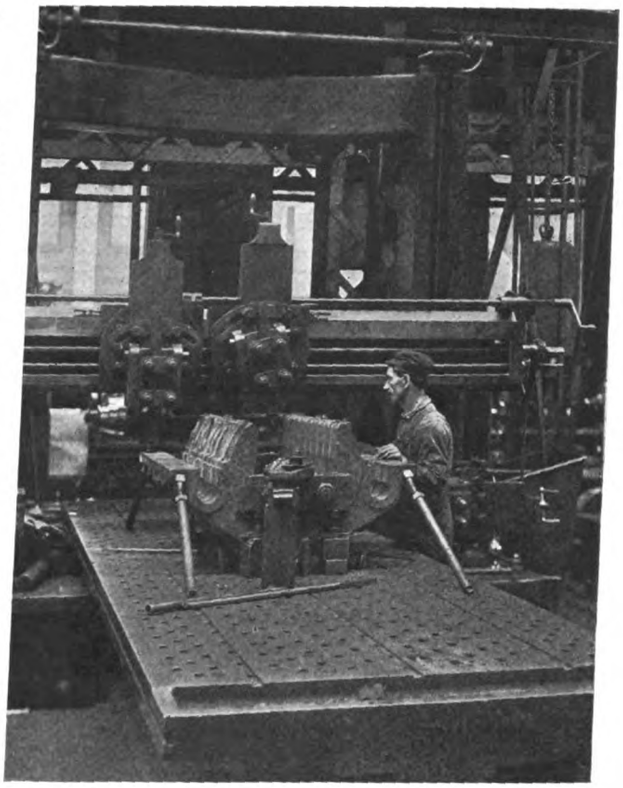

Fig. 17.—Planing Ten Horseshoe Thrust Bearings at One Time

The housings are next set so that the lines on each bottom flange coincide with similar lines on the bedplate, thus bringing the housings approximately to their true position. One long straight-edge is then clamped across the guide faces of the back housings, and another to the sides of the main bearing recesses, each in a horizontal position. Three plumb lines are then hung from boards fastened to the tops of three housings, with their bobs suspended in pails of oil on the floor. The first two (Nos. 1 and 2) are hung from the end-back housings, and set equidistant (using a gage) from the straight-edge clamped to the housings, and the third (No. 3) is hung to a front housing (on the opposite side) and set so that it passes through the center of the main bearing recesses (see Fig. 18).

Housings

The distance from plumb lines No. 1 and No. 2 to the lower straight-edge clamped to the side of the main bearing recesses is gaged to determine if the guide faces are parallel to the main bearing recesses. The third plumb line (No. 3) is used to check the distance from the guide faces to the fore and aft centerline of the engine. Should these points check incorrectly, the housings should be shifted until they are in their correct positions.

Having the back housings accurately set, the front housings are adjusted to their true position from them. Holes are then reamed through the lower flanges, and the bedplate and bolts fitted, and two spots chipped across the joint of each housing for reassembling purposes.

The next step is to prove that the top facings of the housings are exactly on the same plane. This is done by placing a long straight-edge on the facings with a sensitive level on the straight-edge, and using feelers or thickness gages between the housing facings and the straight-edge. This test is applied forward and aft, and athwart-

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ship, and at no place should there be found an error to exceed more than .002 inch. Should a greater discrepancy than this show, the error must be corected by filing or re-machining the faces.

Main Bearings

With the housings correctly set, the main bearings are next fitted. The load on the crank shaft and main bearings, due partly to the weight of the shaft and partly to the alternate push and pull of the connecting rods, is more or less oblique, and is consequently severe, and for that reason no doubtful material or workmanship should, under any consideration, enter into the construction of the bearings.

The bearing boxes are first machined slightly full to allow for fitting; a very thin coat of red lead is applied to the sides and bottom of the main bearing recesses; the sides and bottom of the boxes are smoothed and then tried in place; high spots or tight places are removed with

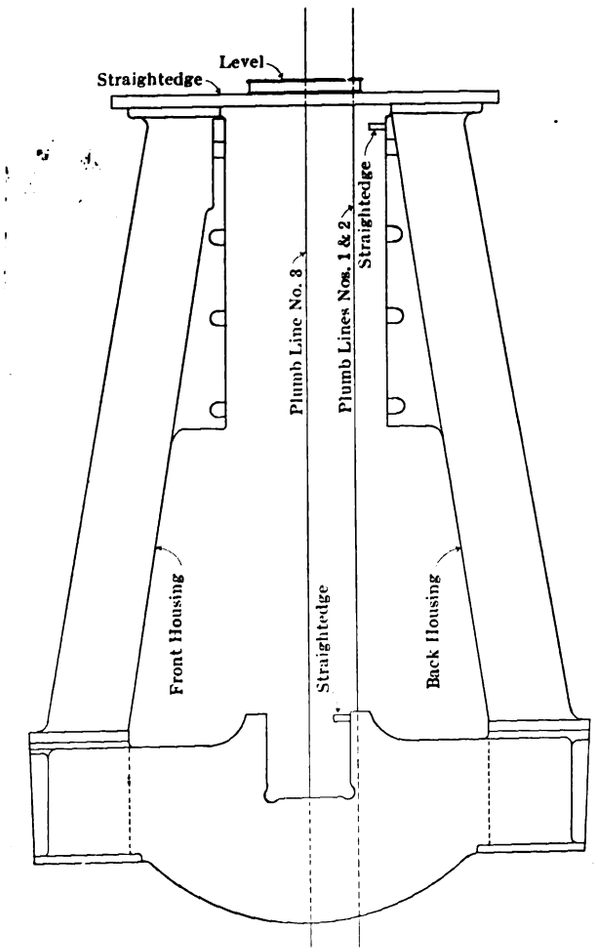

Fig. 18.—Method of Lining Up Housings

a scraper until the boxes show a true bearing on the bottom and both sides. The caps are likewise fitted, after which the distance pieces and liners are put in place, and the main bearing nuts hammered up hard. A fine wire line is then stretched through the main bearings and set central in the main bearing recesses and in the exact location of the centerline of the crank shaft. Having previously tested the wire line, allowance for sag is readily determined, and the wire line raised accordingly in way of each bearing.

From the wire line, five points are accurately located on each end of the main bearings. The wire line is then removed and the main bearings taken out of their places, and set on a horizontal boring mill accurately to the points on each end and bored to size. The oil ways are then cut, after which the lower bearings are put in their final places.

A cast-iron mandrel which has been turned to the diameter of the crankshaft is given a light coat of red lead and placed in the main bearings and rotated a few times. The mandrel is then raised out of the bearings and the

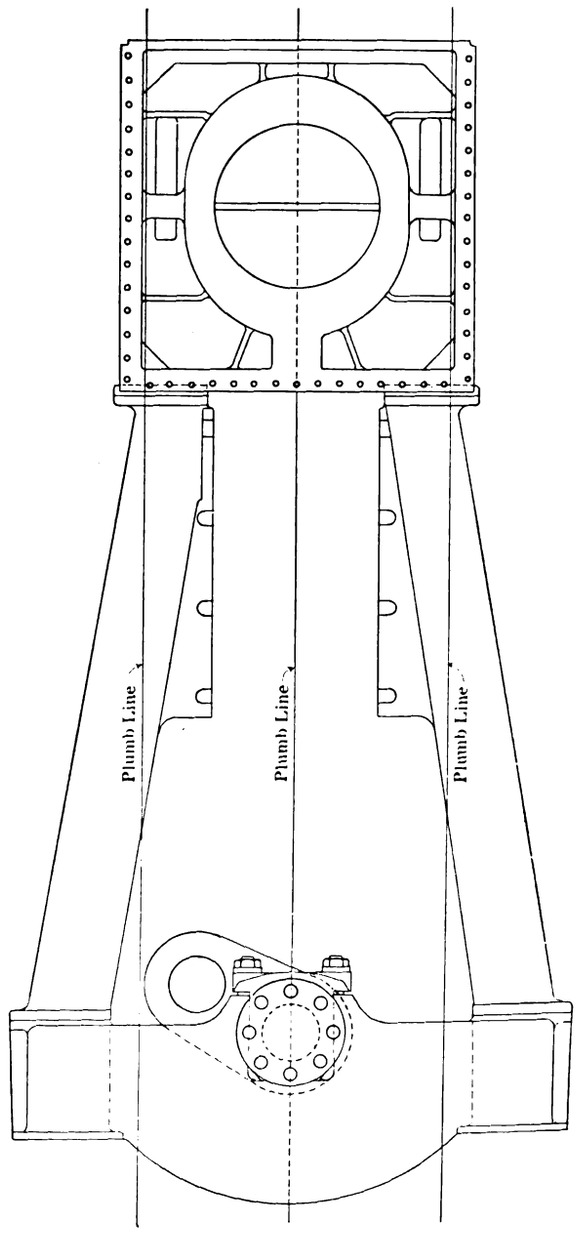

Fig. 19.—Method of Lining Up Cylinders

high spots on the bearings scraped off by hand. This operation is continued until all the lower halves of the main bearings show good-bearing surfaces.

In the engine being described, the crankshaft is long, and is turned in two sections. The two parts are placed in the bearings and set to the required sequence, and the holes are reamed and coupling bolts fitted. The crankshaft is now given a very thin coat of red lead, rotated and then removed. Should any imperfection show, the bearings must be scraped until practically perfect bearing surfaces are obtained.

The main bearing caps are next placed in position so

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they bear on the crankshaft, which is again rotated and, as was done in case of the lower bearings, they are scraped to a fit.

Sheet-metal liners of sufficient thickness to give the shaft .015 inch working clearance are interposed between the bearings and caps; this is to insure sufficient space for a film of oil to lubricate the shaft, when the main bearing-bolt nuts are hammered up tight.

CYLINDERS

The crankshaft having been properly bedded in the bearings, the cylinders are next put in their places and lined up.

In this engine, the second intermediate-pressure cylinder is first erected in place, and is set so that the lines on its feet and those on the housings coincide. Three plumb lines are used in setting this cylinder. One is set so as to pass exactly through the axis of the cylinder and extend down to the floor with its bob suspended in a pail of oil. The other two are hung from the top of the cylinder, equidistant from the first, and near the outer edge of the joint with their bobs likewise suspended in pails of oil (see Fig. 19).

The objective is to set the cylinder so that the line passing through the axis of the cylinder will pass at right angles through the axis of the crankshaft, and that the other lines will be at right angles to the centerline of the crankshaft. The cylinder is carefully shifted until the above conditions are fulfilled, and then it is bolted hard in place. The low-pressure, first intermediate-pressure and high-pressure cylinders are then set in place and a plumb line hung from the top of each cylinder passing through the axis, and set so that it passes at right angles through the axis of the crankshaft.

Having the cylinders set, holes are reamed through the feet and housing flanges and bolts fitted.

REVERSE SHAFT BEARINGS

The reverse shaft bearings, having been previously bolted and doweled in their places, are lined up for boring with a steel-wire line stretched through them, and set at the centerline of the reverse shaft. Points are located for setting on the boring mill as was done in the case of the main bearings. After the bearings are bored, they are finally secured in their places, and the bearings scraped to a true bearing, using the reverse shaft for this purpose.

MAIN ENGINE GUIDES

Guide plates are usually machined slightly oversize in thickness, so that when they are re-machined they will conform to the plans. After machining they are drilled, tapped and thoroughly cleaned, and then subjected to a hydrostatic test of 30 pounds per square inch to insure against leakage of cooling, circulating water. They are then bolted in place and lined up for final work.

It is obvious that when an engine is under steam the temperature of the cylinders is much greater than that of the bedplates; therefore, the expansion of the mass of metal in the cylinders greatly exceeds that of the bedplates. When lining up marine engine guides, this must be taken into consideration; else, when the engine is warmed up the guide faces will be closer together on the lower end than at the top.

The method used for lining them up is as follows: A plumb line is again set central at the top of the cylinder, and passed through the center of the stuffing-box perpendicular to and through the axis of the crankshaft. Then the distance from the guide faces to the plumb line is very accurately gaged from top to bottom, and the condition noted on sketches. They are then taken down and the amount to be machined off is stamped plainly, so that when they are finally put in position they will be gaged to size on the bottom end, and .10 inch smaller on the top, with each guide face, from the bottom to the top, having an inclination of .005 inch toward the center.

After years' of experience this has proved a most satisfactory method of lining and fitting up guides. While

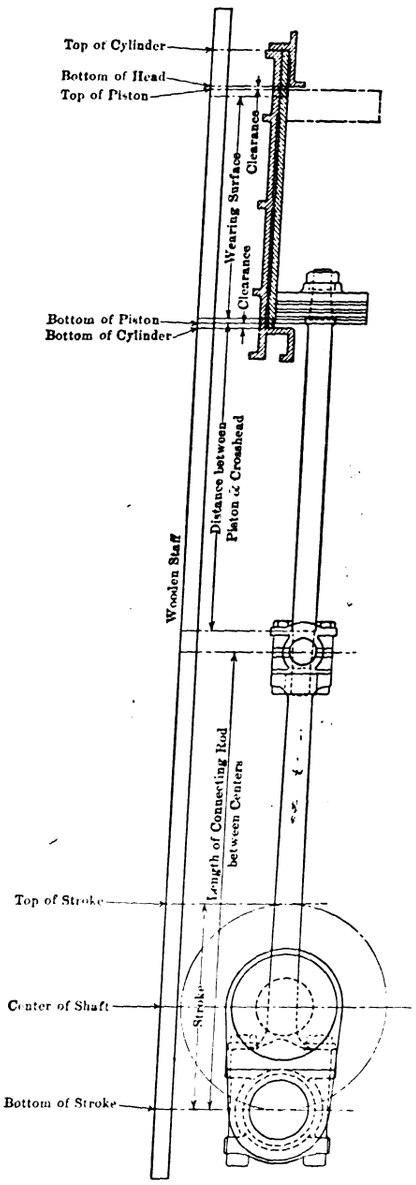

Fig. 20.—Method of Getting Exact Length for Machining Piston Rod

it may be a little expensive and require extra time, the importance of the parts should demand only first-class workmanship.

GETTING CYLINDER CLEARANCES

Definite clearances at the top and bottom of the cylinders are imperative, and they should be marked plainly for the future use of the engineer and for subsequent overhauling operations. Liners should never be interposed between the lower end of the connecting rod and the crank-pin bearings on new work. As previously stated the connecting rods should be machined to exact length

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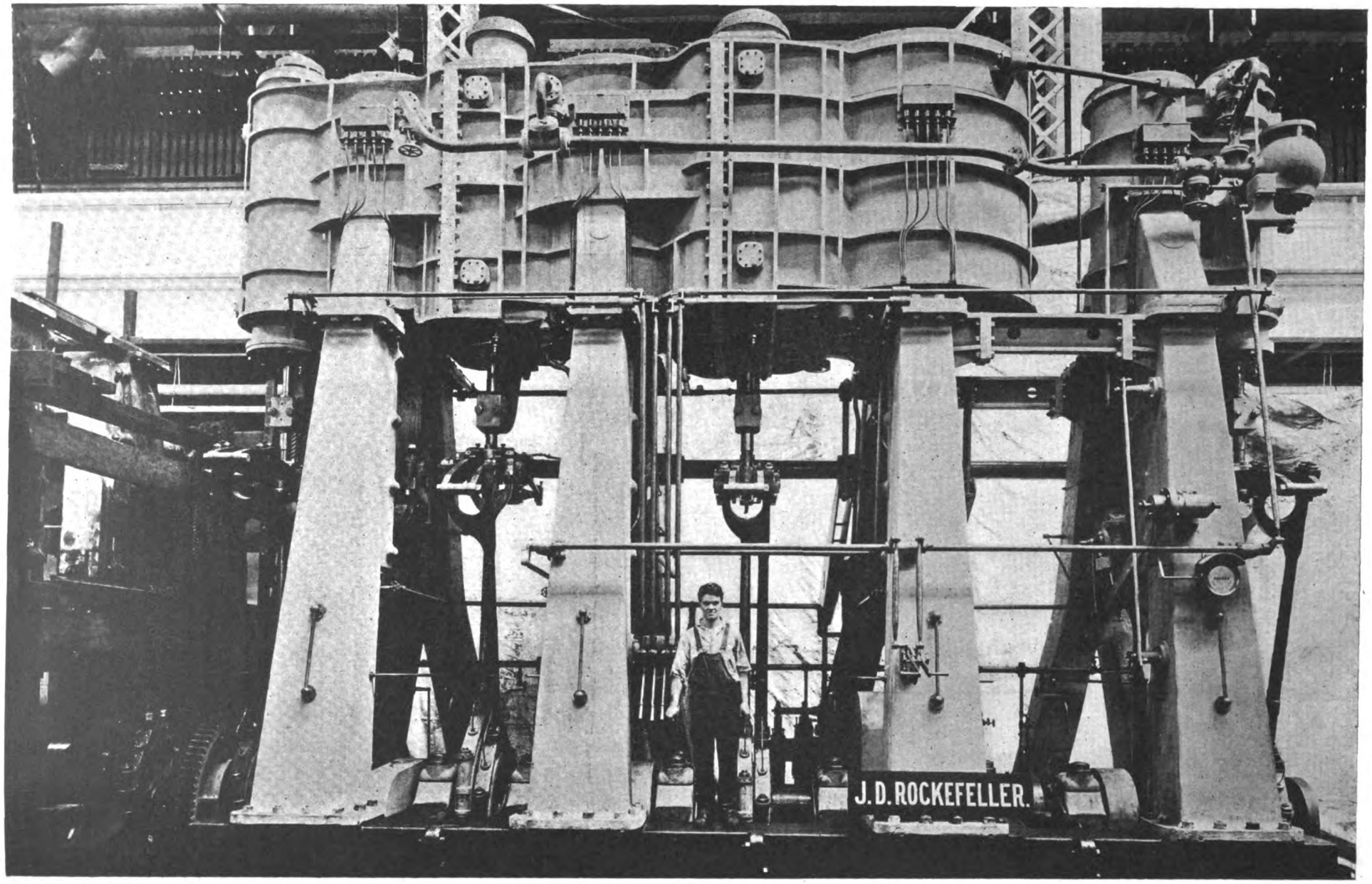

Fig. 21.—Engine Completely Assembled in the Shop and Ready for Disassembling and Installing in the Ship

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between centers. The length of the piston rods should be machined to suit conditions of each cylinder.

To arrive at the exact length of a piston rod, a long wooden staff is placed through the center of the cylinder, extending down below the center of the crank shaft. The top, the bottom, the wearing surface of the cylinder, and the position of the cylinder head are all marked accurately on the staff. From the center of the crank shaft, the center of the crank pin is laid out on the staff at the top and bottom of the stroke. From either the top or the bottom center of the crank pin the length of the connecting rod (from center to center) is marked on the staff. Then from the bottom end of the wearing surface, the piston is marked off so the lower edge of the ring is flush with or slightly over the wearing surface. The crosshead is likewise marked off on the staff.

By measuring the distance between the piston and the crosshead, the exact length for machining the piston rod is found (see Fig. 20).

After the machine work on the piston rods and crossheads is finished they are connected up, and the engine turned over by the turning engine and the top and bottom clearances marked on the guide faces. The bottom striking point is found by disconnecting the connecting rod and lowering the piston until it rests on the bottom of the cylinder. This point is on the guide face. The top striking point is found by pushing the piston up against the cylinder head and this point is marked on the guide face.

The procedure in machining pistons and piston rods is to finish the body of the rod, and then fit the piston rod in the piston and turn the piston on the rod. The crosshead end of the piston rod is left long and large, and is not machined to suit the crosshead until the exact length is obtained from work. In machining pistons they are turned to suit the bore of the cylinder, and the grooves for the rings are machined the correct distance from the top and bottom faces of the piston, so that they will positively overrun the wearing surface on the top end and come flush on the bottom. As the engine wears down, the rings will slightly overrun the wearing surface on the bottom end which prevents the formation of shoulders.

The importance of having proper clearances at each end of the cylinders, and of having the rings in their correct positions cannot be too strongly emphasized.

Hanging Radius Links

Valve gear troubles may often be traced to improperly hung radius links. They should never be hung without proving the accuracy of each connecting part.

First: The bore and the turning of the eccentrics must be parallel one with the other.

Second: The facing on the eccentric strap for the foot of the eccentric rod must be parallel with the bore of the strap.

Third: The bore of the upper end of the eccentric rod and the face of its foot must be parallel with each other, and both at right angles to the axis of the rod.

Fourth: The pins in the link bars must be at right angles to the sides of the bars and in line with each other.

This may be termed the A, B, C, of marine engine building. However, the importance of these details requires careful workmanship.

The link bars are first hung to the valve stem, which is clamped central and firmly in the valve-stem guide. The ahead eccentric rod is then connected to the strap on the eccentric, which has had sufficient liners removed between the joints so that it hugs the eccentric snugly, and is swung to the end of the link bar and the distance gaged from the side of the rod to the bar. It is then swung to the other end of the bar and likewise measured. When it shows equidistant at both ends from the side of the rod, the link bars are in their correct position. The go-astern rod is likewise swung in position and given the same test. If both rods show the same result, they may then be connected to the radius links, and the bearings tried by giving the pins a thin coat of red lead and then bolting the caps on hard. They are then disconnected, and the bearings examined. Should they not show a true bearing they are scraped and the same operation repeated until they do.

Setting Valves

When an engine leaves the hands of the builder the valve gear is, generally speaking, correctly adjusted to give the best possible steam distribution compatible with quiet running of the engine at normal speed. However, the effect of wear of the various parts is to disturb the original adjustment, and consequently the valve gear must be readjusted from time to time.

When the keyways in the crank shaft and eccentrics are accurately laid out and machined, valve setting is only a matter of placing the crank on its dead-center position, with the valve gear thrown in full go-ahead position, and measuring the lead. If it is less than specified, the amount necessary to give it the correct lead is faced off the adjusting collar, which supports the valve on the stem, which is left long purposely for adjusting the valve. The crank is then put on the opposite dead center, and the lead for that end measured, which should be correct. Then the valve gear is thrown in full-gear astern with the crank on its dead center, and the leads on the top and bottom ends checked as was done on the go-ahead gear. If the work has been accurately executed, all leads and laps will be as specified on the valve diagram, and such subterfuges as off-set keys and shimming between the eccentric rods and straps by means of liners will not have to be resorted to.

To set a crank on its dead-center position, first set it approximately correct by eye, then with some standard make of engineers' and plumbers' spirit level applied to one edge of the web and adjusted until the glass shows level. The level is then applied to the opposite edge of the web; and should it show a different reading, the crank is rotated slightly until the reading on the level is identical when applied to either edge of the web. This is a quick, accurate method when the crank webs are properly machined.

Should the machining of the crank webs be uncertain the old method may be used, which is as follows:

When the crosshead is a few degrees away from its highest point, a mark is made on the guide slightly above the upper edge of the crosshead. The engine is turned until the upper edge of the crosshead comes even with the mark. While the engine is in this position, place a tram, both ends of which are pointed, with one end in a center-punch mark made in some convenient part of the bedplate or housing, and make a mark with the other end on the face of the crank web, coupling, or turning wheel, whichever may be the most logical place; then turn the engine off center in the other direction until the edge of the crosshead comes even with the mark. The crank pin will now be the same distance to the right of the center as it was to the left in the first place, or vice versa.

It is evident that the marking point of the tram will not be oposite the mark made, but will make a new mark on the face of the web or coupling. Now make another mark half way between the marks already made, and then

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turn the crankshaft until the tram point is opposite this mark and the crank is then exactly on its top dead center.

In a similar manner, the crank may be placed on the bottom center. To insure accuracy, the tram should be of such a length that the marking point will be approximately in a plane passing through the axes of the crank shaft and cylinder.

If the keyways in either the crank or the eccentrics are not accurately located, the eccentrics will have to be advanced or retarded until the correct lead is obtained and off-set keys are made and fitted to suit.

It is well to bear in mind that moving the eccentric does only one thing, that is, to retard or advance the lead, while raising or lowering the valve on its stem equalizes its travel.

The scope of this article does not permit of a detailed account involving all of the engine details, such as the reversing engine, turning engine, air pump, governor and hand gear, which must respond with the same certainty as the major unit, but the same principles in machining and erection outlined above are involved in their construction and installation, and must be carefully observed to produce a successful engine. Fig. 21 shows this engine completely erected in the shop and ready for disassembling and installing in the ship. The final installation of the engine will require no further machine work.

Present-Day Types of Heavy Oil Engines; Their Limitations and Possibilities

BY WALLAND

THE heavy oil engine, as we know it to-day, covers a seemingly wide range of forms, but this is not so much due to fundamental differences of principle as to constructional and mechanical differences. The tendency to refer to individual makes of engines by their trade names, and place all in the heavy oil engine class, is a healthy sign, as the fuel situation is such as to force the engine builder to adapt his engine to burn whatever grade of heavy oil happens to be most available. Hence it comes that the main object is to produce an engine which will burn any variety of what is known as fuel oil, no matter what its size or application. In time this condition of affairs ought to tend to reduce the number of cycles of combustion, but as for mechanical details there is bound to be a wide variation of forms, due to the variety of types of installation. The final decision in each case must rest on engineering and economical reasons, and time and experience alone will settle just the exact balance.

Diesel Engines Expensive to Build

The premier heavy oil engine has always been, and is to-day, the Diesel engine. It is the standard by which all others can be judged. It is the most economical, as regards fuel consumption, but the most expensive to build; the very mechanical features which make the engine economical of fuel are the ones which increase its first cost. An effort to reduce the first cost and yet not lose too much in fuel economy was the impelling reason which has given us to-day the other forms of heavy oil engine which we have. But we will first consider the Diesel engine in its various forms and what promise it holds for the future.

The majority of marine Diesel engines in use to-day are of the four-cycle type. Small engines fitted with reverse clutches are built in three, four and six-cylinder sizes, but in order to make an engine directly reversible it is necessary to have at least six cylinders, unless some unusual means are used. More than six, except in the case of very large powers where the size of cylinder is a determining feature, simply adds to the number of parts on the engine and takes up increased length, which is always at a premium, without any corresponding advantage. Moreover, a reduction in the number of cylinders for a given power has a tendency to keep down the revolutions per minute, due to the larger size of cylinders; and this is always an advantage in marine work.

Small Engines Are of Trunk-Piston Type

The smallest sized engines, say up to 600-horsepower, are of the trunk-piston type, with a choice of lubrication between the gravity and forced-feed type. The gravity type has the advantage in regard to the amount of lubricating oil flying around in the crank case, and an excess of this means the formation of an oil fog which will tend to work up by the piston rings and cause a large lubricating oil consumption, if not actual trouble with sticky piston rings and carbon deposits. It has the disadvantage of supplying the bearings with only just the amount of oil they need, or perhaps a little more, and if for any cause there is a sudden warming of any bearing, there is no surplus of oil immediately available to take care of the difficulty. It is a fact that with forced lubrication, even with a moderate amount of oil supplied, bearing troubles are very few and far between. With proper piston rings and a good wiper ring at the bottom of the piston, with drain holes to carry off the surplus oil scraped from the cylinder wall, there is, after all, not much trouble due to surplus lubricating oil, and the forced lubrication system has consequently found high favor among engine builders and operators.

There is one important point to be watched, however, and this applies equally well to both systems of lubrication, and that is the pollution of the lubricating oil by carbon from the cylinder walls. This is a disease common to all internal combustion engines where the lower end of the cylinder is open to the crank case, and simply means that from time to time the lubricating oil must be filtered or passed through a centrifugal separator so as to get rid of this carbon.

There is another question which needs to be considered seriously for the small engines, and that is the question of reverse clutches versus reversible engines. A reverse clutch has all the advantages as regards operation except in the rare case of where an engine backs for hours at a time. In this case the clutch gets very hot even though of rugged dimensions. But under ordinary circumstances, with a clutch, the boat can be maneuvered as often as

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desired without any expenditure of starting air, and every one knows, or at least ought to know, that high pressure compressed air on board ship is expensive. Consequently we find that engines are fitted with reverse clutches up to the size where the loads to be transmitted make the clutch unwieldly and more expensive than the reverse gear on the engine, plus the extra air tanks or flasks and other equipment required for a directly reversible engine. The dividing line seems to be between 200 and 300 horsepower, although we find occasional instances of larger engines fitted with reverse clutches or reversing propellers. But if an engine builder is going to fit a reverse clutch on an engine, let him by all means fit one worthy of the name—not a puny, weak affair, but a clutch which will last as long as the engine does with a reasonable amount of overhauling. Pacific coast gas engine builders have established a good precedent in this regard.

Large Four-Cycle Diesels of Crosshead Type

Four-cycle Diesel engines of large powers are pretty well standardized. The majority are of the crosshead type with enclosed crankcase separated entirely from the working cylinders, and fitted with forced lubrication on the principal bearings. There is nothing to contaminate the lubricating oil under these conditions, and it can be used over and over again for a long time with nothing more done than the addition of a little makeup oil. Bearing troubles are practically unknown, and the operator need have no fear because the bearings are enclosed and he cannot see and feel of them. There is only one possible chance of trouble, and that is in the case of leakage of salt water into the lubricating oil, but the engine builder does his part by carefully designing the crank case enclosure, and then the same care must be shown when installing the sump tank in the ship. With a carefully designed and executed installation, most of the trouble in this direction can be eliminated, and it is an important point which needs to be watched in every installation.

There is a growing tendency on the part of engine builders to provide greater simplicity and accessibility. This not only tends to keep down the first cost, but provides for better operation. Nobody can appreciate accessibility better than the operating engineer.

One other point, which is getting more and more attention and yet cannot get too much, is the question of easy and cheap renewal of parts subject to wear. Nowadays, the purchaser of a motorship not only expects the engine to run, but he also expects the engine to last as long as the ship, the same as the steam engine does, with only the usual overhauling. The shipowner has a right to this character of service, and it can be provided without difficulty in a properly designed engine. Let every engine purchased be examined from this standpoint.

Future Development of the Four-Cycle Engine

As for future developments and improvements in the four-cycle Diesel engine, we can expect but little, except perhaps, further perfection of some of the mechanical details. It is a reliable machine, but very heavy and costly. About 325 shaft horsepower per cylinder is the upper limit of size of any engine in service to-day, and while this covers the requirements of practically all cargo ships, especially when installed with twin screws, yet no one supposes that the development of the oil engine is going to stop there. The tendency is towards larger and faster ships, especially in the case of motorships where the extra speed costs so little, and all this means more power. Therefore, the future will require higher powered engines designed on smaller weight and space allowances, and for a lower first cost. On this basis the single-acting four-cycle engine must give way at least for the large powers; it will probably have a field of its own, however, in the moderate powers.

The Two-Cycle Engine

There are very few two-cycle Diesel engines in use in motorships to-day, but this is rather the result of circumstances than otherwise. This type has many advantages for marine purposes, and in the early days of the application of the Diesel engine to the marine field several firms undertook, with very little or no previous experience, to build large engines of this type. The result was that several of the engines were failures. It does take more skill to design a two-cycle engine than a four-cycle engine, because of the more intense heat conditions in the cylinders and the constant downward pressure on the bearings, but with these difficulties overcome by the use of suitable materials and careful design the two-cycle engine looks very attractive. That these difficulties can be overcome is shown by the successful operation of some engines of this type, built by certain firms of extensive experience.

Let us examine the two-cycle engine as compared with the four-cycle for a moment. As already stated, the four-cycle engine is usually built in six cylinders to gain ready reversibility. Now turn this engine into a two-cycle by changing four of the working cylinders appropriately. The new engine will have four impulses per revolution instead of three; hence a smoother turning moment. The cranks will be at 90 degrees instead of 120 degrees; hence better maneuvering ability. Taking the total power of the four-cycle engine as 1, then the power of the two-cycle will be about 1.2, because the mean effective pressure of the two-cycle engine is about 10 percent less than that for the four-cycle engine. But we need a scavenger pump, so we will fit it in place of the other two working cylinders. It will supply four working cylinders, and ought to have 50 percent more displacement than the working cylinders, so that, if we make the pump double acting and the same stroke as the working cylinders, the diameter will be about 1¼ times the working cylinder diameter. This pump will naturally not take up so much room as the two working cylinders, nor so much weight. The air compressor will need to be a little larger for the two-cycle engine, but the increase in space and weight required will be only a small percentage of the total. The net result of this change, then, is an engine of the same cylinder size and revolutions as before, but developing 20 percent more power on less space and weight. Is it any wonder that the two-cycle engine has so many followers?

The two-cycle engine has a fuel consumption about 5 percent higher than the four-cycle engine. On the other hand it is simpler mechanically, particularly in connection with the reversing gear details. Engines of 500 and 600 shaft horsepower per cylinder are in successful operation to-day, so that this type offers much larger powers than any other which is immediately available.

Possible Mechanical Changes

What is needed, however, is not higher-powered engines, but engines which are simpler and cheaper than our present-day types. There are two methods of attacking the problem—one is by a change in mechanical arrangement, and the other is by a change in principle, with the resulting change in mechanical arrangement.

The two best examples of a change in mechanical arrangement are the opposed piston or Junkers type of engine, and the double-acting engine. The opposed piston

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type is excellent as regards balance, small weight and space, absence of valves and ease and thoroughness of scavenging, but the mechanical arrangements for getting the power from the piston to the crankshaft and for cooling the pistons are not so attractive. A few firms have undertaken to develop this type of engine and claim great success with it, but in general it has found very little favor. The double-acting engine, on the other hand, offers many advantages without leading into any awkward mechanical difficulties.

It is possible to build a double-acting four-cycle engine, and in fact a certain firm in Germany attained quite a reputation with its tandem double-acting four-cycle engine several years ago, but these were of the horizontal stationary type. It is not likely that an engine of this type would be attempted for marine purposes because of inaccessibility and an awkward arrangement of valve gear. A double-acting four-cycle engine with one cylinder per crank is possible, but compared with a double-acting two-cycle is so unattractive mechanically that probably this type also would be abandoned in favor of the latter.

The two-cycle double-acting engine is everything that a reciprocating steam engine can be for turning movement, balance, maneuvering ability, and more, since each end of each cylinder is a complete power plant in itself. This type can readily be built in anything from two cylinders upwards. There is a positive reversal of pressure on all bearings, which should eliminate all trouble in this direction, no matter what particular system of lubrication is adopted. Almost twice as much power can be developed at a slight increase of space and weight as compared with the single-acting engine of the same number and size of cylinders, or a better solution is to reduce the number of cranks, which naturally tends to increase the size of cylinders and reduce the revolutions per minute.

All these advantages offer considerable incentive for the development of such an engine, and some progress has been made. Germany produced such a machine, after several years' experimental work, in 1914, but what has happened since then we do not know. Several other firms in other countries have also done considerable experimental work. Some of the problems, such as the piston rod stuffing box, have been solved, but the best arrangement of combustion chamber, valve gear, and design of cylinder and piston must be worked out in the light of extensive experience. This type of engine offers such attractive possibilities that it looks like one of the engines of the future.

Possible Changes in Principle of Operation

A good example of an engine simplified by a change in principle is the so-called solid injection type. This type of engine omits the air compressor for supplying compressed air for atomizing the fuel, and depends upon a high pressure and a special form of nozzle to accomplish the same purpose. In England such an engine has been developed employing the same cycle of combustion and duplicating the ordinary Diesel engine mechanically except for the omission of the air compressor and some slight changes in the fuel system. In this country, an engine working on the Otto cycle with a compression pressure of about 200 pounds per square inch, and a maximum pressure of from 400 to 500 pounds per square inch, has been developed and is now being built by several companies. Both designs are of the four-cycle type. They show as good or better fuel economy and develop as much power for a given size of cylinder as the ordinary four-cycle Diesel engine. Consequently they show a distinct saving in weight and space, and ought to be cheaper in first cost. To date they have not been built in very large powers per cylinder, 100 shaft horsepower being the limit in this direction, but this type is comparatively new and there is no reason so far as the principle is concerned why it cannot be built in the same sizes as a Diesel engine.

Mechanically, this type does not offer much simplification, since the working cylinder details follow the Diesel engine very closely. They have to be made reversible for marine purposes, of course, and a reversible four-cycle engine is not particularly attractive mechanically. To be sure, they are made to work, and very reliably too, but the large number of parts required for the purpose are a constant inducement to all engine designers to try and accomplish the same result in another and simpler way. However, this type is an advance, and offers much for the future.

Surface Ignition Engines

There is another type of solid injection engine which is in an entirely different class and goes under another name, that is, the surface ignition type. It was first built a good many years ago, and to-day has become thoroughly standardized. The typical engine is of the two-cycle port scavenging type, with the lower side of the working piston and the crank case acting as a scavenger pump. It works on the Otto cycle, and since the low compression does not give heat enough for ignition of the fuel some auxiliary means, as a hot tube, bulb, or coil, is necessary.

It is about the simplest and cheapest of oil engines that can be conceived, but its virtues end with that statement. The scavenging is poor, principally because the displacement of the scavenger pump is only equal to the volume of the working cylinder. Furthermore, the hot bulb generally forms a pocket by iteself which is not readily scavenged, due to its shape. All this means that there is a lack of pure air in the combustion space at the end of compression, and if the air is not available the fuel cannot be burned. These engines develop only from 40 to 50 percent as much power in a given size cylinder as does the ordinary two-cycle Diesel engine. Of course, this naturally means that for a given power the cylinders must be large and the engine correspondingly heavy. The fuel consumption is at best a third more than for a Diesel engine.

The lubricating oil consumption is also very high, due to the use of the crank case as a scavenger pump. Any surplus oil from the crank or wrist pins, and there must always be some surplus in order to avoid burned-out bearings, is picked up by the scavenging air which is always rushing through the crank case, and some of it at least is carried up into the working cylinder and lost. Modern designs fit special devices on the main bearings to prevent loss of lubricating oil from them, so that the lubricating oil consumption has been reduced to some extent.

Let it not be thought from this that the surface ignition engine is to be universally condemned. It has a place, but the size of that place is limited. Most engines of this type are of small powers and the requirements of most such cases call for reliability and low first cost. The surface ignition engine meets these without difficulty. Its very simplicity makes it reliable and low in first cost. Its comparatively large weight for the power is mostly cast iron, and is taken care of in the foundry. As far as the installation is concerned the extra weight is no objection. The total amount of fuel consumed and its low price make the fuel bill moderate, so that its relatively high fuel consumption is not a seriously objectionable point. The question of lubricating oil consumption is different, and unless the design of the engine is such as to keep this within

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reasonable limits it may make the difference between success and failure.

Surface ignition engines are offered for sale in sizes up to 125 shaft horsepower per cylinder. Some builders use reverse clutches for all sizes, others make all sizes directly reversible, while others steer a middle course, making the larger sizes directly reversible and using reverse clutches on the smaller sizes. This type of engine can be made reversible very easily, and it would seem to be the better way for the larger sizes where the reverse clutch begins to assume undue proportions. The real field for the surface ignition engine is in the small powers. It does not offer much chance for improvement because of the principles of its design; and if these are changed, then it will no longer be the simple, cheap engine it is to-day.

An Improved Surface Ignition Engine

There is an engine built on the Pacific coast which falls in the general class of surface ignition engines, but which has been so changed in principle and mechanical detail that it deserves separate attention. It has been built in only one cylinder size of about 100 shaft horsepower to date. Both four-and six-cylinder engines have been built, and they are made directly reversible. It is of the two-cycle, port scavenging type, and is fitted with crossheads and an open frame. The lower end of the cylinder is enclosed and is used as a scavenger pump. In addition there are double-acting scavenger pumps on the back of the engine. These latter pumps are driven from the working cylinder crossheads by the ordinary beams and links. The important point, however, is these extra scavenger pumps which provide more air for the working cylinders. The result is an increase of about 30 percent in the power developed as compared with the ordinary surface ignition type, with the same size of cylinder.

As already mentioned, this engine has an open frame and is fitted with crossheads. Drip lubrication is used, and in fact the lower part of the engine looks exactly like a great many marine steam engines. This brings the engine nearer to established marine practice; and with the increase in power gained at the comparatively slight expense of additional scavenger pumps, this type marks a distinct advance. Note that the modified construction avoids the heavy lubricating oil consumption of the ordinary surface ignition type. It is a cheap design of engine to build, and has all of the virtues and few of the faults of the ordinary type. While it offers some chance for improvement in mechanical details and in principle of combustion, there is a limit to the latter, and in this respect it is in much the same position as its prototype. That is to say, if the principle of its operation is changed in a marked manner in order to reduce the fuel consumption or increase the power per cylinder size, it will lose much of its simplicity and attractive characteristics.

The Hvid Engine

There is another type of engine which has only recently come into prominence, but which promises to be a very serious competitor of the surface ignition type, and that is the Hvid. It is of the four-cycle type; uses the same compression as the Diesel, and without the necessity of an air compressor or high pressure fuel pump burns the same fuel with as good an economy. A needle valve controls the amount of fuel which flows into a cup in the cylinder which controls the combustion. It develops as much power per cylinder size as a four-cycle Diesel engine, and except for the fuel valve and cup the mechanical design follows the general lines of the Diesel more than any other type. It is available to-day, however, only in comparatively small sizes, about 25 shaft horsepower per cylinder being the limit. It has been standardized in design by several builders and is an appreciably cheaper engine to manufacture than the Diesel engine, although more costly than the surface ignition type. The small powers in which it is built make the reverse clutch not only available, but very attractive; and hence it has been neither necessary nor desirable to develop a directly reversible engine. This type of engine is also very satisfactory for use as an auxiliary generator engine on board motorships. It uses the same fuel as the main engines with as good economy, it is readily governed, and is cheap to manufacture.

It offers little opportunity for development of the principles of combustion; but this is no disadvantage, since it is already as good as the best. There is little room for improvement mechanically, since here again it has reached a high state of development. The greatest chance for advancement seems to lie in the application of this principle to larger cylinder sizes, especially for auxiliary generator work, and in the application of this engine to marine work in general in substitution for other types.

Possibilities of the Gasifier

There is still another type of engine which has only very recently been introduced into this country, and which consists of a so-called gasifier that can be applied to either a two- or four-cycle engine. The engine, aside from the gasifier, follows the usual lines of construction. This gasifier is a chamber attached to the cylinder, and the fuel is first injected into it, where a slight explosion takes place, which drives the main body of the fuel into the cylinder. The same high compression, about 500 pounds per square inch, is used as in the Diesel engines, and the same variety of fuels can be used with as good an economy. The power developed per cylinder size is not as much as in the Diesel, but is more than in the surface ignition type. To-day, this type is built in this country in very small powers only, up to about 15 shaft horsepower per cylinder, and all of the engines are of the two-cycle type. Its simplicity of operation, its excellent economy, and its fair mean effective pressure make it very attractive. Comparatively speaking, it is only in the early stages of its development, and what its future will be, time alone can tell, but it certainly looks as though it had possibilities.

Conclusions

In conclusion, let us view the field broadly, first taking up the general requirements for marine heavy oil engines for all services, and second, examine the several types available for these services.

Every marine engine must be reliable, and if it is not reliable, then no matter what other virtues it may possess, it is useless for marine purposes. The quality of being reliable covers not only the absence of mechanical breakdowns but also perfect combustion, which will remain perfect over very long periods of operation. Fuel valves, which will clog up for any reason, or imperfect combustion, which results in carbon deposits or pitting of valves, are conditions which cannot be tolerated. The marine heavy oil engine must be adapted to burn a fairly wide variety of fuels with little or no change in adjustment, and with perfect combustion results, since a motorship trades all over the world, buys its fuel in the best available market and the characteristics of fuel oil change according to the oil field from which it is obtained.

Accessibility for the parts which need inspection or adjustment is almost as important as reliability, for no man will give an engine proper attention if an extraordinary amount of work is necessary. The engine must be reasonable in first cost, or it will take too long for the economy it will show over a steam installation to pay for

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the difference. plus the extra fixed charges. The parts which will wear must be capable of ready and cheap replacement in order to keep down the cost of repairs. This is increasingly important as the size of engine increases. The engine must be simple enough in design, so that the average engine operator can understand the functions and the necessary adjustments of the various parts without difficulty. The design must be rugged enough so that the engine can stand a reasonable amount of abuse. Of course, any piece of machinery ought to be operated properly at all times, but the fact remains that the contrary sometimes happens, and so far as possible the design should be such as to minimize the evil results from this.

Marine heavy oil engine service can be divided into two general classes, propulsion and auxiliary generator. For propulsion purposes, with powers not exceeding about 50 shaft horsepower, we have available to choose from, engines of the surface ignition, Hvid, and gasifier type. Nearly all of the engines of this power are fitted with reverse clutches and most of them require compressed air for starting. Some of the very small sizes, however, are arranged to be started by hand. The surface ignition type is the oldest, and hence there are more manufacturers of this type than the other two, but the advantages of the other two types are sufficient to warrant a careful investigation by the purchaser before plunging too heavily into engines of this size.

For engines from 50 to 100 shaft horsepower, we have a choice of the surface ignition, Hvid, and Diesel types, Most of these engines have reverse clutches, some of the surface ignition engines being directly reversible, and all require compressed air for starting. A Diesel engine in this size is so expensive and the advantages over the other two types are so slight that it is not a serious competitor commercially. In this size, again, the surface ignition engine is manufactured so widely that it almost has the field to itself, but the Hvid type has made a start and ought, in time, to get more attention.

The next step in size is from 100 to about 600 shaft horsepower. Here the choice narrows to the surface ignition and Diesel types. The Diesel engine in this power is generally of the four-cycle trunk piston type and does not require any special piston-cooling arrangements. Within this range the dividing line is reached between reverse gears and directly reversible engines. The nearer the upper limit of this range of power is approached, the more the advantages of the Diesel engine are apparent, and it may be said that in reality the surface ignition engine is a competitor of the Diesel only over the lower part of the range from 100 to 600 shaft horsepower. The solid injection type also enters the upper part of this range of power, but this can be regarded more as a simplified form of Diesel than anything else.

For powers over 600 shaft horsepower the Diesel type in some form has the field to itself. It is a question of either two or four cycle, with the two cycle in favor as the power increases. Beyond this comes perhaps the double-acting engine, but this is in the future. All engines of this size have crossheads and conform to established marine practice.

For auxiliary generator service, the requirements call for a stationary type engine with a maximum power of about 200 shaft horsepower. Most of the engines of this type, however, are of very much less power, and this opens a field for the Hvid type of engine. A few engines of this type have been fitted, but the majority have been of the four-cycle Diesel type. There is also a need for a small emergency engine of about 5 to 10 shaft horsepower, which can be started by hand. A surface ignition engine of this size connected to a generator would be most useful. It could furnish power for a small compressor to supply starting air in case the regular supply became completely exhausted from any cause; it could supply power for the wireless, even if all other power on the ship were lost; and it could supply lights, and even some power for regular service when the ship is in port, and it is not necessary or desirable to run one of the regular generator sets.

What is the general tendency in heavy oil engine design? The general tendency is always towards a simpler and cheaper engine without sacrificing other advantages too much. There probably will be modifications of the combustion cycles used to-day, and these will involve changes in mechanical details, but the main idea back of them all will be the same. Time and experience under actual working conditions, and not laboratory tests, can alone settle the best balance and determine the best type for a given set of conditions.

Development of American Motorships

TO the American-Hawaiian Steamship Company of New York belongs the credit of departing from the beaten path of American experiments in small motor vessels, by ordering two freighters of 11,200 tons deadweight capacity, powered with two Burmeister and Wain type Diesel engines, having an indicated horsepower of 4,500. The ships will be about 460 feet long and will be built at the Chester, Pa., yards of the Merchant Shipbuilding Corporation. The engines will be built by the William Cramp & Sons Ship and Engine Building Company, Philadelphia.

Pacific Coast shipyards are also rapidly developing in motorship construction. Pursuing the policy of expanding its fleet of motorships, the Standard Oil Company of California has recently placed contracts with the Moore Shipbuilding Company, Oakland, Cal., to build a tanker of 5,010 tons deadweight capacity and 2,000 indicated horsepower. The main propelling machinery will consist of two Werkspoor engines, which are being built by the Skandia Pacific Oil Engine Company, Oakland, Cal.

In addition to the motorships under construction in the United States, firms developing marine Diesel oil engines of various types are preparing for a demand for units of higher power by building engines up to 2,300 horsepower. The Skandia Oil Engine Company is carrying on the construction of twenty-five 850-1,000 brake-horsepower Werkspoor oil engines. At the Fore River plant of the Bethlehem Shipbuilding Corporation experiments are also being conducted on high-power machines.

McIntosh & Seymour, Auburn, N. Y., James Craig Engineering and Machine Works, Jersey City, N. J., and the Worthington Pump & Machinery Corporation, New York, are all building four-cycle Diesel type engines of about 2,000 horsepower.

Although the two-cycle Diesel engine has certain features to recommend its trial in American ships, the Busch-Sulzer Bros. Diesel Engine Company, St. Louis, Mo., is the only firm at present building high-powered units of this type. The largest of these now under construction is of 2,300 horsepower.

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A Review of Motorship and Marine Diesel Engine Building in Europe

BY OUR SPECIAL LONDON CORRESPONDENT

THE first large motorship was put into commission in the early part of 1912, so that before the outbreak of war there was comparatively little time for any widespread development to be made in Europe. While the war was in progress none of the shipbuilders in the belligerent countries was able to devote much attention to this phase of shipbuilding and work was necessarily held up in the neutral countries, owing to the shortage of material and other circumstances connected with the war. The result was that by the time the armistice was declared motorships had not come to the fore as much as they might have done under other conditions. The events of the past year have, however, proved that the claims made for the motor vessel are fully justified, and the very large numbers of orders that have been placed, in many cases by owners of existing motorships, demonstrate that complete confidence is placed in this new type of vessel.

Motorships Building Total Nearly 1,000,000 Tons

There are at the present time between 110 and 120 motorships on order in European shipyards, the majority of them having a deadweight capacity of about 10,000 tons each. The total deadweight carrying capacity of these vessels is between 900,000 and 1,000,000 tons, while the power of the machinery installed is in the neighborhood of 300,000 indicated horsepower.

These figures, large as they are, represent only comparatively a small proportion of the motor vessels that could be contracted for, if it were possible to obtain reasonable deliveries. The chief difficulty which is now encountered is that every marine oil-engine manufacturing firm in Great Britain or on the Continent, which has had any prolonged experience in this work, is so fully occupied that it is impossible to carry out any more work or give deliveries within the next year or eighteen months. Every effort is being made to cope with the demands and new factories, specially equipped for Diesel engine manufacture, are being erected by some of the oldest established shipbuilders. It is particularly interesting to note that the leading firms on the Clyde are making a very strenuous effort to overtake the Scandinavian shipbuilders who have gained such a considerable lead in this industry, owing to their enterprise in embarking upon a policy of marine oil-engine manufacture at a time when most shipowners and shipbuilders looked askance at this new departure.

An idea of the relative position in the motor shipbuilding world can be gaged from the fact that of the motor vessels mentioned above, 40 are on order in Denmark, 22 in Great Britain, 20 in Sweden and 13 in Holland. France is, however, making little headway and details are not yet available regarding the work which is being carried out or is contemplated in Germany. It is stated, however, that the Germans intend rebuilding their mercantile fleet, practically entirely with motor vessels; and when it is remembered that before the war German engineers had perhaps gone as far as those in any other countries in marine oil-engine development, it will not be surprising if considerable progress is made in Germany when things become more settled in that country.

One of the most notable features in connection with the development of the motorship is a very definite tendency towards standardization among shipbuilders and shipowners. It will readily be understood that this type of ship lends itself specially to construction of large numbers of exactly the same type mainly for the reason that the machinery can easily be standardized, thus costing much less to build and being capable of manufacture in a considerably shorter time. The shipowner, too, realizes the advantage of having several ships in which the machinery is duplicated, since this avoids the necessity of having large numbers of spare parts and at the same time diminishes the risk of breakdown.

Standardization of Motor Vessels

It will be interesting to examine the three main classes of motorships which may be said to represent the standard types of vessel now being constructed in Europe, and which as a matter of fact account for quite 90 percent of the internal combustion engined ships now under construction. In the first place there is the largest type of all, with a deadweight carrying capacity of 13,000 to 13,500 tons, 465 feet in length, with a beam of 60 feet and a draft of 31 feet 6 inches. Over 20 of these vessels have been contracted for in Great Britain and Scandinavia; but while in the latter countries the machinery power comprises two sets of 2,250 horsepower, the British ships are fitted with machinery of the highest-powered Diesel motors yet built, these being two 3,200 horsepower sets, giving the vessel a speed of about 13½ knots. It is distinctly to be noted that owners of motorships are more and more tending to increase the speed of these vessels, by installing high-power machinery. Quite the majority of motor vessels now being built are designed to develop a speed of 11½ to 12 knots, and many of 13½ to 14 knots. One of the reasons is that the fuel consumption in these vessels, as compared with a coal-fired steamer, is so small that the great disadvantage of the average high-speed cargo steamer, namely, high fuel costs, scarcely enters when the vessel is propelled by internal combustion engines.

The second type of standard vessel is one carrying from 9,500 to 10,000 tons of cargo, 425 feet in length, with a beam of 56 feet and a draft of about 25 feet 6 inches. In nearly all these vessels, two six-cylinder engines of about 1,500 brake horsepower are installed for a designed speed of 11½ to 12 knots, and many shipowners consider this class to be the most successful and economical for the general carrying trade especially on very long voyages. It is significant in this connection to note that the three shipowning firms with the greatest experience in running motor vessels have many of these 9,500-ton ships on order, the concerns in question being the Glen Line in Great Britain, the East Asiatic Company in Denmark, and the Johnson Line in Sweden.

The third standard vessel is a 6,500-ton deadweight carrying craft, 367 feet in length, with a beam of 57 feet and a draft of 25 feet, generally equipped with two 1,000 indicated horsepower Diesel engines, which give a speed of about 11½ knots. This class of ships has also proved extremely economical in service and is in fact the most popular among shipowners who, for one reason or another, do not care for the larger sizes. Actually there are more 6,500-ton motorships on order than of any other

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type and Norwegian shipowners in particular place great faith in such vessels. It has been shown in the course of many years of service that such a motorship equipped with two 1,000 horsepower engines, having a speed at sea of over 11 knots, will operate regularly on a fuel consumption rather lower than seven tons of oil per day of 24 hours. As these ships are generally designed with a bunker capacity of 1,000 tons of oil they can take on fuel at the cheapest ports and practically be independent of other stations, no matter how long the voyage may be.

TYPES OF ENGINES

One of the most noteworthy points in motorship construction is the success achieved by the four-cycle type of engine. In more than four-fifths of the vessels already built and those under construction this design has been adopted, and on the whole it has certainly proved more reliable in actual service than the majority of the two-cycle engines. It must not be supposed, however, that European ship and engine builders have lost faith in the two-stroke motor; for, on the contrary, some of the most remarkable developments are now being made in connection with engines of this design. So much more experience has been obtained with four-cycle engines that they have gained a lead which it will take some years for the two-cycle engine builder to make up; but there are such obvious theoretical advantages in engines of the latter type that should all the practical difficulties be thoroughly overcome it is not unlikely that such motors would become more generally used than other types. The demand for higher powers may also lead towards this end, for while the four-cycle engine has with some difficulty been gradually built up until engines of 3,000 indicated horsepower can be constructed, two-cycle motors of over 4,000 brake-horsepower have been manufactured for stationary work and one of the leading Diesel engine manufacturing firms in Europe is prepared to build 6,000 brake-horsepower-two-cycle engines, under guarantee, and it is doubtful whether four-cycle engines can reach this power in the near future.

Dealing first with four-cycle engines, practically only three types have made any headway in Europe, these being the Burmeister and Wain, developed by the firm of this name at Copenhagen; the Werkspoor, built in Holland by the Werkspoor Company, and the Vickers engine, which has been so widely used in connection with installations in submarines for the British and other navies. As is well known, the former was the first large marine engine to be produced, and in the pioneer motorship *Selandia* two eight-cylinder engines of this design developing 1,000 indicated horsepower were installed. This gave a specific power of 125 horsepower per cylinder and now motors of the same type are being built in Great Britain by Harland and Wolff of 3,200 indicated horsepower in eight cylinders or 400 indicated horsepower per cylinder. It will be noted therefore that considerable development has been made in the intervening years, and it is believed that engines up to 5,000 indicated horsepower can be constructed in the near future to the same design.

More than half the motorships now being built will have Burmeister and Wain engines installed, and it is particularly noteworthy that, apart from comparatively minor modifications, there are no differences in the construction in essential features as compared with the first engines put into commission. One of the chief differences is perhaps the universal adoption of a self-contained three-stage high pressure air compressor on each engine for the injection air for the fuel, since in the earlier types only a single-stage high pressure air compressor was fitted taking air at about 220 pounds per square inch from an auxiliary compressor situated in the engine room driven by a separate oil engine. This arrangement has proved fairly satisfactory, but there is little doubt that the self-contained engine offers greater advantages.

Another change in the design is in connection with the supports for the cylinders, which are now partially carried on steel columns in the larger engines and not wholly on the cast-iron framework as in the earlier types. Moreover, a lantern piece is interposed between the bottom of the cylinder and the framing through which the piston rod can be seen and which also serves for the collection of any lubricating oil dropping down from the cylinders so that it does not fall into the crank chamber. All the other important features in the engine remain the same as in the 1912 type, and it must be admitted that this is very creditable to the original designers. The reversing system has proved so entirely satisfactory that it has never been touched and in ships operating with engines of this type reversing is carried out within five or six seconds and years of service have proved that motorships can thus be handled much more readily and with greater safety than steamers of the same size.

The two other leading types of four-cycle engines, namely the Werkspoor and the Vickers, have both shown distinct developments since the conclusion of the war. In the case of the first-named engine, improved methods of reversing have been devised, but the most important progress has been effected in the increase in the size of engines constructed. Motors are now being built of this design developing 2,140 horsepower, and designs are prepared for 4,000 indicated horsepower sets, although hitherto the largest size has been about 1,300 horsepower. This is an indication of the greater confidence which is being gained in marine oil-engine construction, and these engines of 2,140 horsepower are of the six-cylinder type with cylinder diameters of 26 inches. At present the largest size of cylinder operating on the four-cycle principle has been built by Harland and Wolff, in which the cylinder diameter is 29 inches. It is difficult to say how far this can be increased without involving insuperable cooling difficulties, but most designers believe that sizes up to 35 inches are possible. In this connection it may be noted that the design of the Werkspoor cylinders is different from that adopted by Burmeister and Wain, in that cylinders are arranged in pairs of three, each unit being contained in what is virtually a water tank forming the jacket with the liners fitted separately into this tank.

SOLID INJECTION DIESEL ENGINES

The modification of the Vickers engine to render it suitable for mercantile ships is perhaps one of the most important developments in Diesel engine construction in England. In essential operation, the Vickers engines for cargo ships are similar to those installed in a very large number of submarines, and the manufacturers are so confident of their solid injection system of fuel that they are employing it on every class of engine now being built. They have converted their submarine-engine shop into a factory for constructing slow-speed mercantile engines and numerous motors are now being built. The oil pressure at which a solid injection system works is over 4,000 pounds per square inch, and one of the most remarkable facts in connection with this arrangement is the low fuel consumption which is obtained, for figures below 0.4 pound per brake-horsepower-hour have been reached.

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At present the largest engines being constructed for actual service are 1,250 brake-horsepower, six-cylinder sets with cylinders 24½ inches diameter and 39 inches stroke, but some very big experimental engines are now under construction at the maker's works, and it may be possible to give details of these at a later date.

Two-Stroke Engines

From the purely engineering point of view the work which has been carried out in Great Britain and on the Continent on two-cycle marine engines is, perhaps, of the greatest importance. When it is borne in mind that some of the most renowned shipbuilders in the country are now busily occupied in developing two-cycle motors it may well be realized that the supremacy of the four-cycle engine is likely to be seriously challenged in the course of the next few years. For it cannot be denied that once the two-cycle engine gains an equal reputation for reliability to that which is now enjoyed by the four-cycle the advantages of the former in the matter of reduced weight, lower initial cost and smaller space occupied cannot fail to have an influence upon the minds of shipowners and superintendent engineers. Even in the question of fuel consumption the four-cycle engine will scarcely show to any advantage; for, in the latest types of marine Diesel engine of the Sulzer construction, fuel consumptions of 0.41 pound per brake-horsepower-hour have been reached, which is only three or four percent above those of the most economical four-cycle engines.

This Sulzer engine, which has been considerably modified during the past year or two, offers one of the most likely solutions of the problem as the application of two-cycle engines to ships; and it is especially interesting to record that its manufacture has been taken up in England by Armstrong, Whitworth and Company, Ltd., who since the conversion of their naval yard to mercantile shipbuilding work probably possess the best facilities in the whole of Europe for turning out a large number of hulls.

There is scarcely any question in the minds of European designers that the successful two-cycle engine must be of the valveless type. This principle has been adopted in the Sulzer engine for many years, but in the latest design (of which several sets have recently been completed for installation in Danish and Norwegian ships) some novel arrangements have been adopted. As is perhaps well known, the general principle of scavenging in these engines lies in the provision of two sets of scavenging ports, one above the other, close to the bottom of the cylinder and opposite the exhaust ports. The bottom row of ports is uncovered by the piston in the course of its stroke, admitting scavenging air at about 1½ pounds per square inch, but during this period the top row of scavenging ports does not admit scavenging air, as the inlet is closed by a semi-rotary valve. Just before the bottom row of scavenging ports is closed by the piston on its upward stroke, this rotary valve is opened and admits an excess supply of scavenging air to the cylinders, thus thoroughly cleansing out the whole of the cylinder of exhaust gases and filling it with pure air for the compression stroke. Originally a double-beat valve was employed for this purpose; but the rotary valve is found to be a great improvement and there is little trouble that can be experienced with it in connection with leaking, since it is never exposed to a high temperature.

Another important modification that is being adopted in the new Sulzer-engined ships is that instead of driving the scavenging pumps direct off the engine, as has been done in previous types, these pumps are entirely separate and are driven by means of electric motors, being themselves of the turbo-blower type.

The advantage of this is that the engine is shortened and an increased efficiency of scavenging is obtained, while the scavenging pressure and the quantity of scavenging air can be varied according to circumstances; while at starting the engine can be warmed by heating the scavenging air before admission to the cylinders. This is an entirely novel departure in motorship practice, and is one that will be watched with the greatest interest by motorship engineers.

Some Novel Designs

Of the other types of two-cycle engines that have made great strides during the past year, none is more interesting than the two opposed piston designs developed respectively by Cammell Laird, of Birkenhead, and Doxfords, at Sunderland. The former is so fully described elsewhere in this journal that there is no need to repeat the details of its construction except to remark that the first ship in which one of the motors is installed has just been completed and another vessel with two larger engines developing 1,000 brake-horsepower is almost ready for its trials.

The Doxford engine, in a way, inaugurates a new phase of motorship construction, since the builders have already standardized a certain type of engine for installation in single-screw motor cargo ships, which are themselves also standardized. The novelty in this lies in the adoption of a single-screw installation, for the vast majority of motorships built and on order are twin-screw vessels. The reasons that have led the builders to this decision are that the type of engine which they are constructing is essentially suitable for large powers, and moreover, owing to the fact that it is of the opposed piston type, it runs at a lower speed of revolution than the ordinary design. They have therefore standardized a 3,000 indicated horsepower four-cylinder set which runs at 77 revolutions per minute, and this is eminently suitable for installation in the average type of cargo vessel of 11 or 12 knots, where a low propeller speed is desirable for high efficiency. One point about this arrangement is that when steamship owners come to the conclusion, as they inevitably will, that the steam engine is too expensive to operate, they will be able to take out the whole of the steam plant and replace it by one of these Doxford engines without removing the stern gear or propeller. The advantage of this opposed-piston type for high powers can be gaged from the fact that 3,000 indicated horsepower are developed in the four-cylinder engines with the cylinders only 22¾ inches in diameter. A six-cylinder, four-cycle engine with cylinders 29 inches in diameter has an output of only 2,250 indicated horsepower, so that the possibilities of the opposed-piston type for large powers are clearly far greater than those of the four-cycle design.

There are in addition several very novel features in the Doxford engine. Solid injection is utilized by means of a mechanical pump working at a pressure of 6,000 or 7,000 pounds per square inch, while in the second place the compression pressure is very much below that which is usually considered desirable for a Diesel motor. It is in the neighborhood of 300 pounds per square inch, instead of about 480 pounds per square inch, thus allowing lighter scantlings than would otherwise be necessary. In order to achieve this, however, the tops of the pistons are maintained at a high temperature, the principle thus corresponding in a certain degree to the maintenance of a high temperature in the hot bulb of the cylinders of a hot bulb engine. When starting up, the engine has to be

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warmed by passing hot water through the jackets, but otherwise there appears to be no great disadvantage in the system to counterbalance the obvious advantages which will be achieved.

A point in connection with these valveless two-cycle engines is that they can undoubtedly operate on a poorer grade of oil fuel with less detriment than the four-cycle type with its exhaust valves. This may be a point of considerable importance in the future, since fuel oil is not improving in quality, and a ship which can operate on the least pure grade will thus be a distinct advantage.

THE ECONOMY OF MOTORSHIPS

The economies which are now being effected by European motorships are so large that at first sight it appears they might be exaggerated. This is, however, not the case, and one or two examples of actual vessels in commission will prove what astounding results are being achieved. One instance may be given of a motorship of 6,500-tons deadweight carrying capacity which has been on the Scandinavian and North and South American run for seven years. She is a vessel of 11 knots and has a fuel consumption of 7 tons of oil per day, and owing to contracts being still in existence which were made before the war the actual cost of fuel to the owners is less than $48.70 (£10) per day. A similar steamer burns 33 tons of coal which costs $24.35 (£5) per ton, giving a total of $803.55 (£165) per day, or a saving in favor of the motorship of $754.85 (£155) each 24 hours the vessel is actually in commission.

Another case that may be mentioned is in connection with two vessels of exactly the similar size owned by the Atlantic Transport Company trading between England and the United States. These vessels carry about 6,500 tons (the motorship carrying about 350 tons extra on the same dimensions); and while the fuel consumption of the motorship is 11 tons, that of the steamer is 40 tons per day, the respective costs of fuel being $267.85 (£55) and $974 (£200), which represents an economy for the motorship of $706.15 (£145) daily.

A third instance lies with two 10,000-ton eleven-knot vessels on the Eastern run between Great Britain and India, one a motorship and the other a steamer. The former burns 10 tons of oil at a cost of $194.80 (£40) per day, while the latter consumes 36 tons of coal at a cost of $1,051.92 (£216), the saving in this case being $857.12 (£176) daily.

These figures represent actual facts and are typical of the savings which are being made in motorships at the present time; and there is a further point which is of extreme importance, namely, that whereas the steamer invariably consumes more fuel the longer it is in service, it is found that at the end of seven or eight years' commission the engines of a motorship burn exactly the same quantity of oil as the day the trial trip was run.

THE QUESTION OF RELIABILITY

Shipowners will agree that this economy is highly satisfactory, but it would be entirely nullified unless it can be shown that the motorship compares favorably in reliability to the steamer and that the cost of upkeep of the machinery is not very much higher than that of a vessel in which steam engines or steam turbines are installed. It is true that cases may be cited where considerable troubles have been experienced, and in fact in one or two ships it must be admitted that the oil-engine machinery has been replaced by steam power. Actually there have probably been not more than two or, at the most, three conversions on a large scale, and wherever it has been carried out it is due to the fact that the oil engines installed were of an experimental type upon which insufficient experience had been gained in the workshops before the motors were actually fitted in a ship. It applies almost wholly to two-cycle engines, which in the early days of Diesel engine construction gave considerable trouble, owing to an incorrect design being adopted. Such engines are no longer being built (for the most part they were valve-scavenging engines instead of the port-scavenging type which is now universally adopted), and in the modern designs all the possibilities of breakdown which were then presented have been overcome.

Leaving aside these few instances of unsatisfactory operation, the large number of motorships that have been put in service from the beginning of 1912 onwards have proved remarkably reliable. It is difficult to give facts proving the degree of reliability which has been attained, since owners of motorships are apparently none too anxious for the rest of the world to know how economical these vessels have proved to be. An instance, however, may be quoted of a Scandinavian motorship, the *Pedro Christophersen*, which has now been in commission for the past seven years, and which for the past two years has never had a shore engineer on the ship to carry out any work of repair. For the past twelve months of operation the repair bill, including all replacements and spare parts, has not exceeded $1,461 (£300), which is, of course, far lower than the average steamer of the same size, bearing in mind the attention which has to be paid to boilers on these vessels. No overhaul has been carried out for over two years and even the cylinder covers have not been removed for more than twelve months.

Again, the motorship *Selandia*, the first large internal combustion engined vessel to be put on the sea, has now been in regular commission for the past eight years, and during that time has had no serious breakdown of any sort. She has run altogether about 400,000 miles and many of her trips have been from 30 to 40 days on end with a non-stop run. Moreover, the fleet of motor-cargo vessels for the Glen Line, which are now engaged upon the runs between Great Britain and the East, are making their trips with the complete regularity of the old-time tramp. Quoting from a letter the writer recently received from an engineer on one of the largest of these ships, "they run with such absolute regularity that there is no comment to be made at all upon the engines." The repair bill on this fleet is, according to the information in the possession of the writer, rather lower than that for corresponding steamers, and out of the seven or eight ships which are now in daily service, no reports have been received of any breakdown at sea or any serious trouble ever being experienced since the first vessel was put into service.

Perhaps the most conclusive proof of the reliability of motorships, however, lies in the fact that each of the shipowners who have gained experience with motorships when placing repeat orders invariably contract for vessels fitted with Diesel motors. This applies almost without exception to every motorship-owning firm, and, in confirmation, names of such well-known concerns as the East Asiatic Company, the Glen Line (controlled by Lord Pirrie), the North Star (Johnson) Line and the Anglo Saxon Petroleum Company may be quoted, who between them own from 40 to 50 motorships, and have now an equal number on order, in each case, practically to the entire exclusion of steamers. It is perfectly clear that had motorships proved in any way unreliable, or had the cost of upkeep of the machinery been excessive, this obvious proof of the confidence now felt in the internal combustion engined vessel would not have been given.

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The New Cammellaird-Fullagar Opposed Piston Type of Marine Oil Engine

BY OUR SPECIAL LONDON CORRESPONDENT

The new marine oil engine which has just been brought out by Messrs. Cammell Laird and Company, Ltd., the well-known shipbuilders of Birkenhead, is probably the most novel type that has yet been developed. The chief advantages which are claimed for this motor are that its weight, and therefore its cost, for a given power is lower than with any existing type, while the space occupied is smaller. Futhermore, it is of a design which is essentially capable of being manufactured in very high powers.

IF the claims for the Cammellaird-Fullagar opposed piston type of engine are substantiated, it is clear that the new engine must find a very wide field of application, and the builders have already engaged upon a policy of manufacture of standard engines of 1000-horsepower for installation in single or twin screw cargo ships. It is hoped in the near future to build motors of this type up to 4,000 brake horsepower, and still larger sets are already contemplated.

The principle of operation can be seen from the drawings, Fig. 2 and 3. The reproduction from a photograph represents the first mercantile engine, which is a motor of four cylinders, 14 inches in diameter with a total stroke of 40 inches developing 500 brake horsepower at 120 rev-

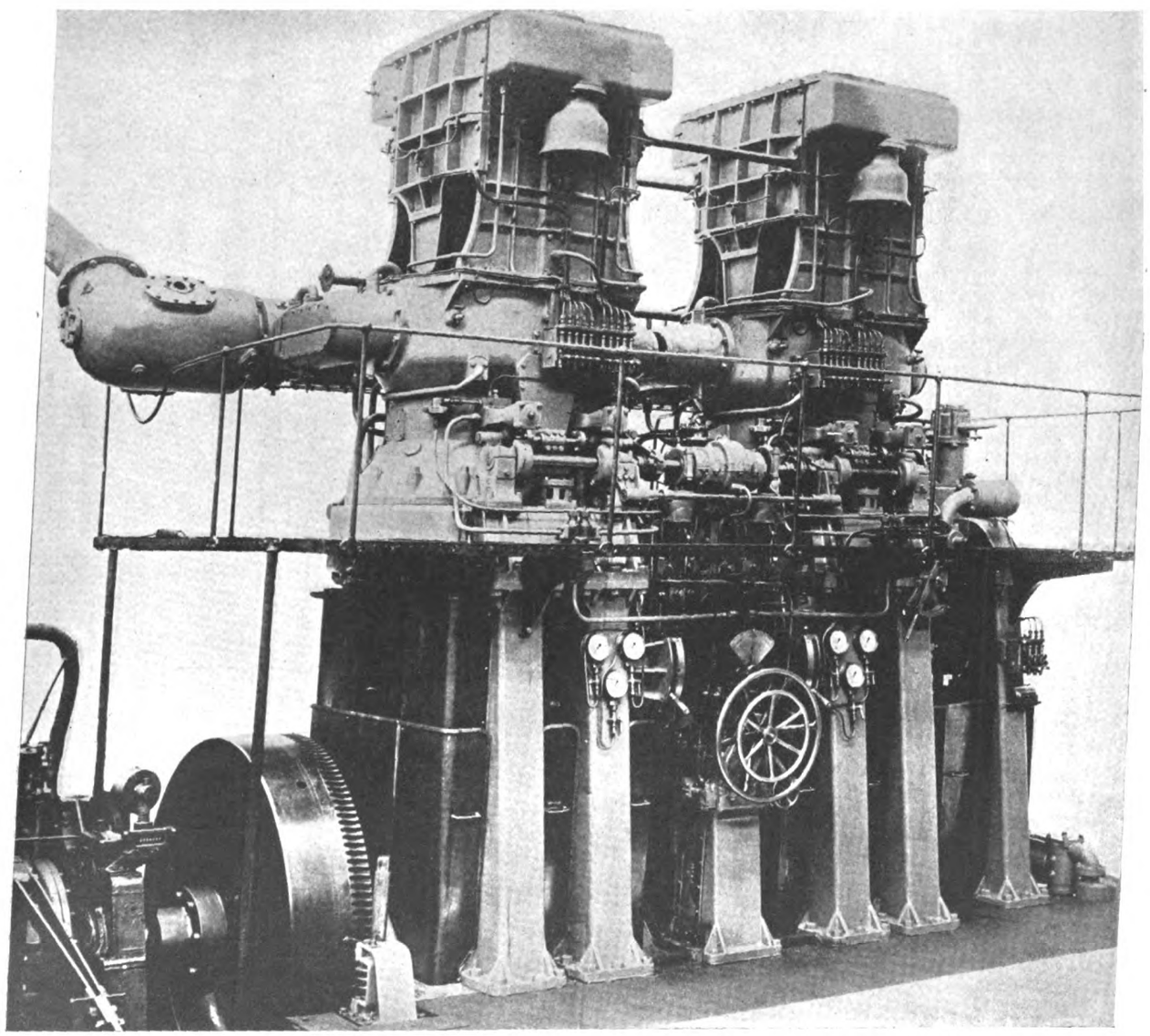

Fig. 1.—500-Horsepower Cammellaird-Fullagar Marine Oil Engine for Installation in an Electrically Welded Ship

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olutions per minute. This motor is to be installed in an electrically welded coasting vessel which is approaching completion in the yard of the builders of the engine.

Each unit consists of two cylinders, with a common water jacket, in which are carried two separate liners which form the cylinders, these being open both at the top and bottom. In each cylinder are two opposed pistons, moving inwards and outwards together. The cranks of two adjacent cylinders are set at 180 degrees, so that when the pistons of one cylinder are at their nearest point of approach those of the next cylinder are furthest apart. The crossheads of the top pistons are joined by means of two diagonal rods to the crossheads of the bottom adjacent pistons, so that there is a resulting cushioning effect, which reduces the load on the bearings and enables a lighter framing to be employed than with ordinary motors. Each unit of two cylinders is carried upon two cast-iron columns, which on the inner side form the crosshead guides. There is no bearing between two adjacent cranks, so that the length of the engine is relatively small; and as the motor is of the open type, all parts are readily accessible.

INJECTION OF FUEL

In other respects the Cammellaird-Fullagar engine, as it is called, follows much along the lines of the ordinary opposed piston design. The fuel is injected by means of

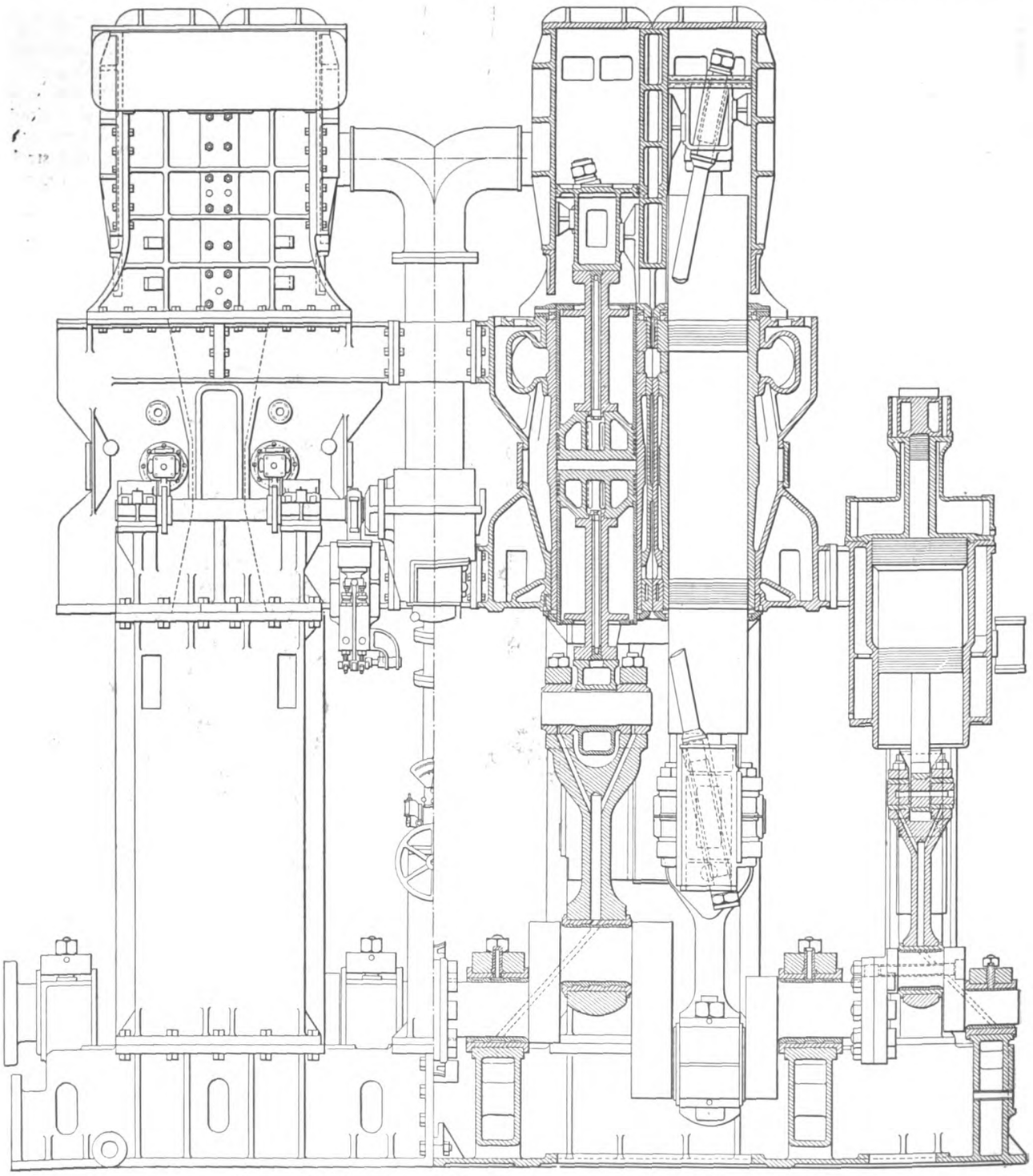

Fig. 2.—Side Elevation and Partial Section of Cammellaird-Fullagar Engine

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a centrally placed fuel valve, just before the pistons reach their nearest central point, the combustion chamber being thus formed between the tops of the two pistons. Right at the bottom of the cylinder are arranged ports all around the circumference through which scavenging air is admitted when these ports are uncovered by the bottom piston in the course of its stroke. Exhaust takes place through a similar series of ports right at the top of the cylinder, these being uncovered in their turn by the upper piston just before the end of its stroke. The scavenging air thus passes right through the whole cylinder and a very good scavenging effect is obtained, giving the engine a high efficiency for a two-cycle type, the fuel consumption being 0.42 pound per brake horsepower hour.

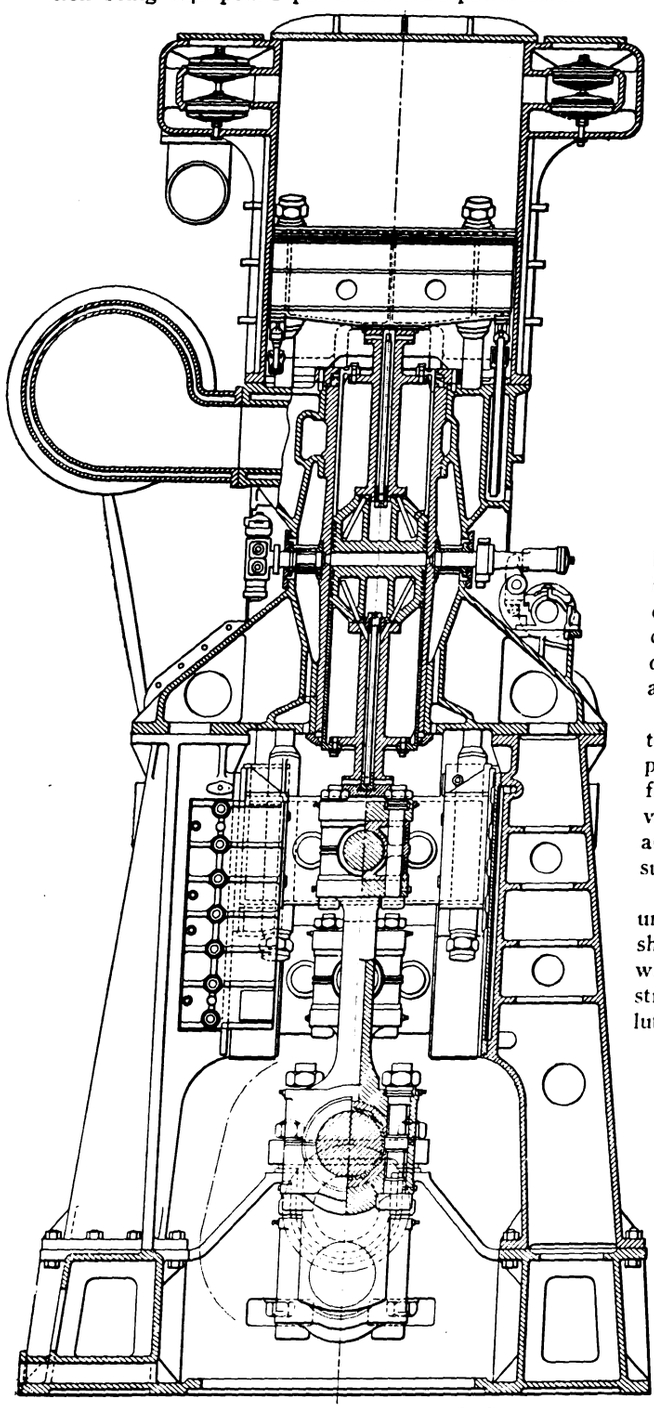

Fig. 3.—Cross Section Through Cylinder

The scavenging pumps are very simply designed by boxing in each top crosshead, which thus forms the piston of its scavenging pump. In this way, floor space is saved, while there is practically no increase in the height of the engine beyond what would be necessary were the scavenging pumps arranged either at the forward or after end of the engine. The air supply both for the injection of the fuel and for starting purposes is obtained from a three-stage vertical air compressor driven from a crank off an extension of the crankshaft at the forward end, while the two pumps for the circulating water and lubricating oil are also fixed at this end of the engine, driven from eccentrics and being of the plunger type. The lubricating oil is also used for cooling the pistons, which is a system that has been frequently adopted for Diesel engines, but in large sets fresh water would be utilized.

VALVE GEAR

The fact that only the fuel and air-starting valves have to be accommodated leads to a considerable simplification of the gear. The camshaft, which can be seen just above the top of the engine framing, is driven from the crankshaft by means of bevel gearing and a vertical shaft. There is only one horizontal fuel valve for each cylinder, and this is actuated by means of short levers from cams on the camshaft. When reversing, this camshaft is turned through a small angle by rotating the reversing wheel in front of the engine which lifts the vertical driving shaft mentioned above, thus causing the camshaft to be partially rotated. The cams are thus set relative to the crankshaft at the right timing to open the fuel valves in the correct position for astern running. The starting air valves are at the same time set in a position to admit compressed air to the right cylinder when the starting wheel on the front of the engine close to the reversing wheel is turned by the operator. By this movement the compressed air is first supplied to all four cylinders. A further rotation of the starting wheel cuts off the air supply from two cylinders, and admits fuel, while the final movement shuts off all the air and admits fuel to the four cylinders which are then operating under normal conditions.

The speed of the engine when running is controlled by the hand throttle on the right-hand side of the starting platform, this causing more or less fuel to be by-passed from the delivery side of the fuel pump to the suction valve. There is another hand lever which controls the admission of injection air so as to reduce the quantity supplied when the engine is running at low speed.

Two further engines of 1,000 brake horsepower are now under construction for installation in a 6,000-ton motorship. These comprise two units of two cylinders each with cylinder diameters of 18½ inches, and a total piston stroke of 50 inches. The power is developed at 110 revolutions per minute.

Globe Repair Yard to Have Crandall Dry Dock

The Globe Shipbuilding & Dry Dock Company, Baltimore, Md., is to have at its new repair plant a 9,000-ton floating drydock of the latest design. This dock is of the longitudinally-trussed sectional type, designed and developed by The Crandall Engineering Company, drydock engineers, Boston, Mass. It measures 440 feet over the keel-blocks and 83 feet between the wing walls. The pumping is accomplished by 24 electrically operated centrifugal pumps, the control of which is so centralized with indicators that the dockmaster may readily govern the pumping in all the compartments of the dock.

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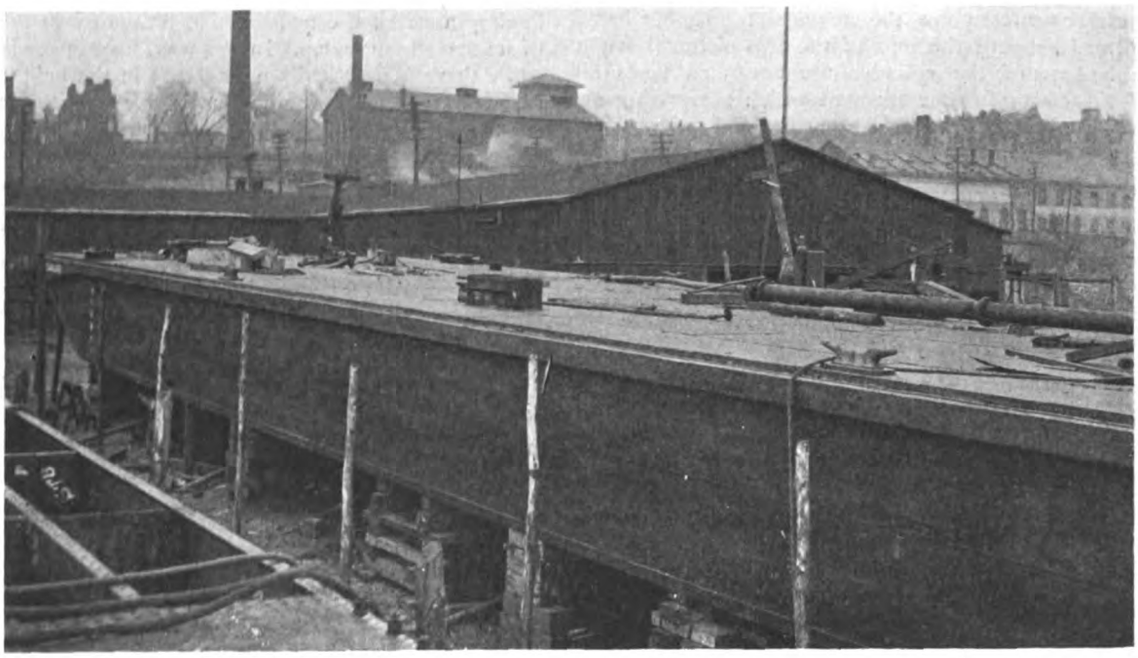

Fig. 1.—Riveted Barge Ready for Launching. The Same Ways Were Afterwards Used for Construction of Welded Barge of Same Type

Electrically Welded Ships

BY WILLIAM T. BONNER*

That shipbuilders and shipowners do not take welding more seriously is deplored by the author, since to both must come great gains not alone in prestige and efficiency of service but also in remuneration. Many examples of the saving of time and materials required for the fabrication of ship's parts are cited in this article as proof of the claim that electrically-welded jointures are stronger, more efficient, and yet cheaper than riveted work. From what has actually been accomplished, it is perhaps not unreasonable to expect that ere long ship welding will come into its own.

THE earliest undertaking of record wherein electric welding was exclusively employed in the fabrication of important strength members of sea-going vessels was that carried out by the writer at Newburgh, N. Y., on the Hudson River, in April, 1917. The vessel was a 1,200-ton bulk oil barge designed for service in Mexico. Her dimensions were: Length, between perpendiculars, 165 feet 3 inches; breadth, molded, 37 feet 9 inches; depth, 8 feet 6½ inches. The shell and deck plating was of ¼-inch, while the transverse framing members, intercostals and the like, were all of 5/16-inch plating. As may be noted by reference to Figs. 4 and 5, the arrange-

* Engineer, welded ship construction; member Society of Naval Architects and Marine Engineers; American Bureau of Welding and American Welding Society.

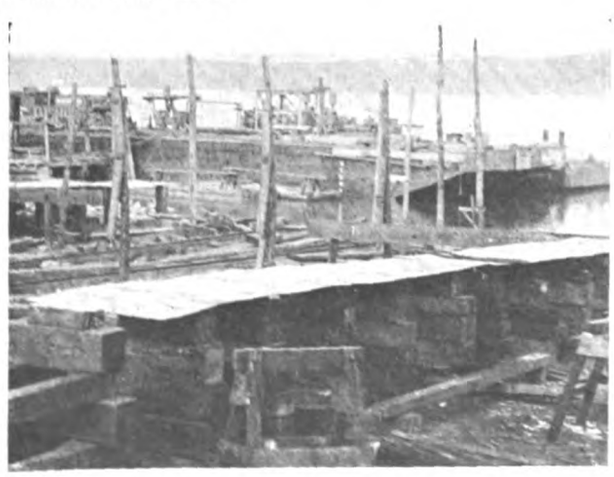

Fig. 2.—Keel Plates for Welded Barge. Note Badly Buckled Condition of Plate Edges. Latter Were All Drawn Up Perfectly Straight for Welding Without Use of Bolting Holes

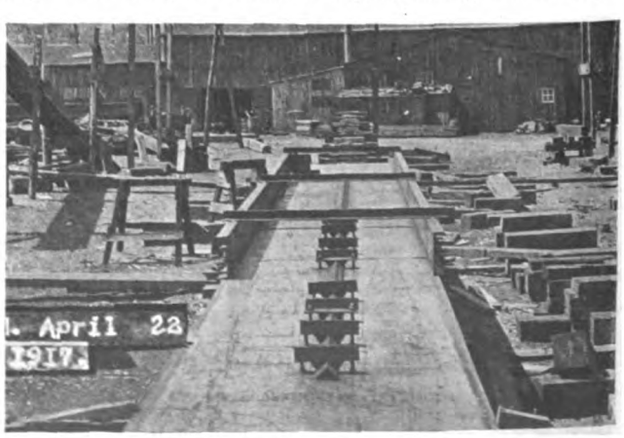

Fig. 3.—Keel Plating with First Longitudinals and Bottom Support for Centerline Bulkhead "Tacked" in Place. Note How Plate Edges Have Been Straightened.

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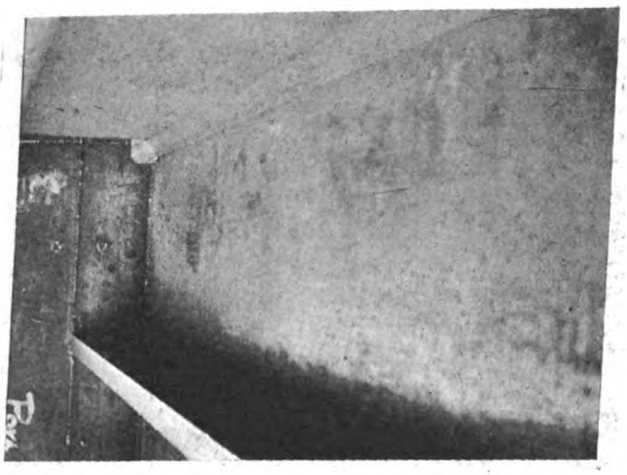

Fig. 4.—Finished Connection Between Centerline Bulkhead and Underside of Deck Plating with Inboard Section of Transverse Frame

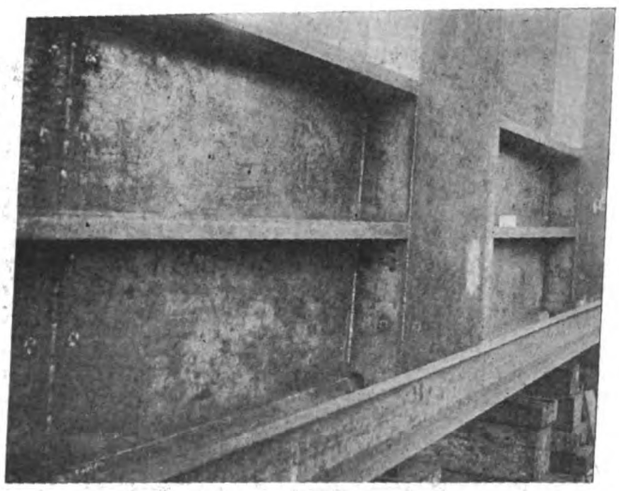

Fig. 5.—Looking Aft Along Port Side of Centerline Bulkhead, Showing Longitudinal Bulkhead Stiffeners and Bottom Longitudinals with Inboard Portion of Transverse Frames

ment of longitudinal and transverse framing followed the Isherwood design, while, generally, the selection of materials and details of construction were carried out in accordance with Lloyd's specifications.

After completing the principal midship section by welding, the remaining portion of the barge was constructed by riveting in order to compare construction and maintenance costs of the two types. The welded section extended from the watertight midship bulkhead to the forward transverse bulkhead, also watertight, and included the keel plates with adjoining longitudinal bottom strakes, and the entire superimposed centerline bulkhead structure with inboard portions of the intermediate transverse frames. Thus it will be seen that the section of the barge selected for welding included a considerable portion of the most important strength members, and the results

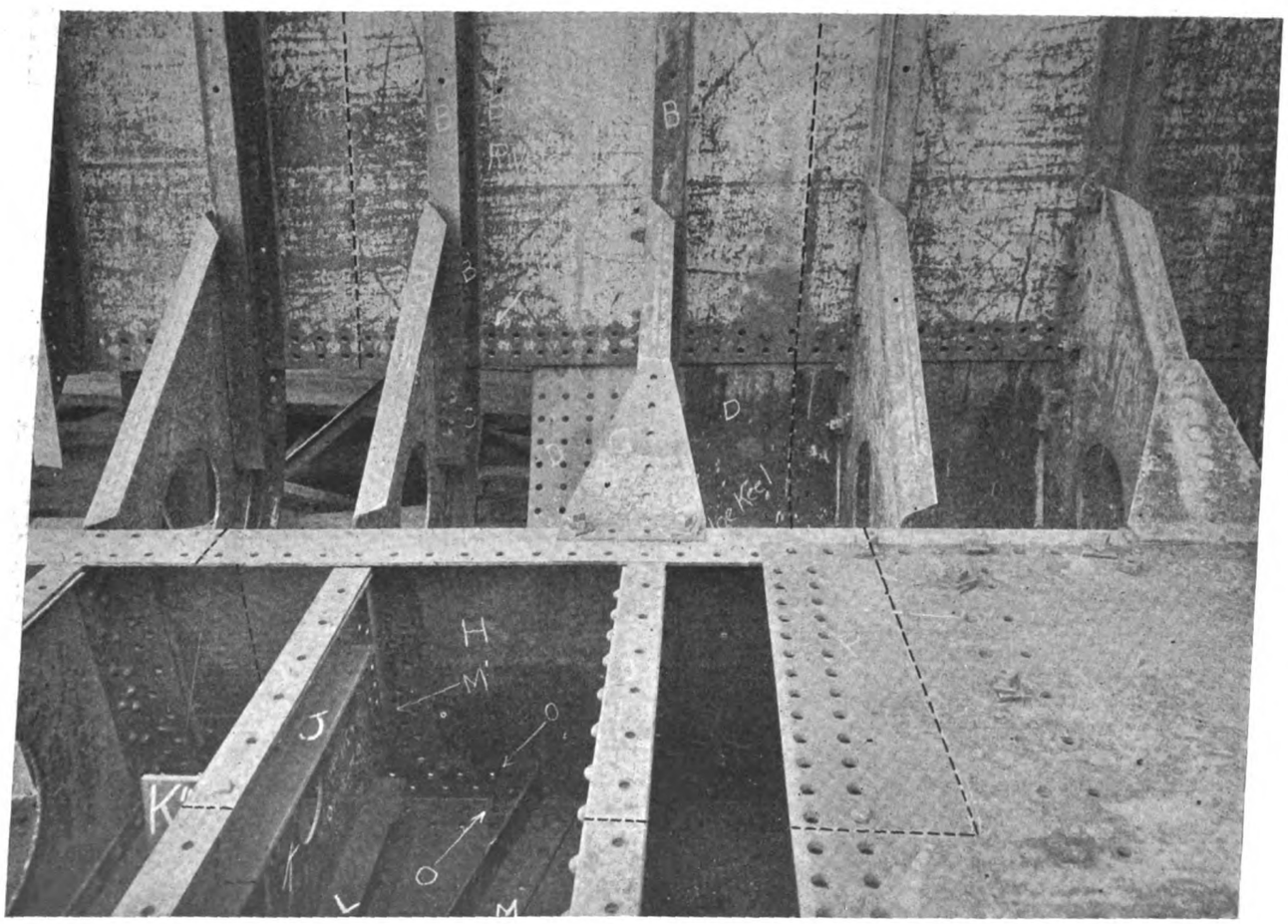

Fig. 6.—Portion of Bilge of 10,500-Ton Cargo Ship Defined by Dotted Lines Shown for Comparison with Welded Section of Same Size and Shape Shown in Fig. 8

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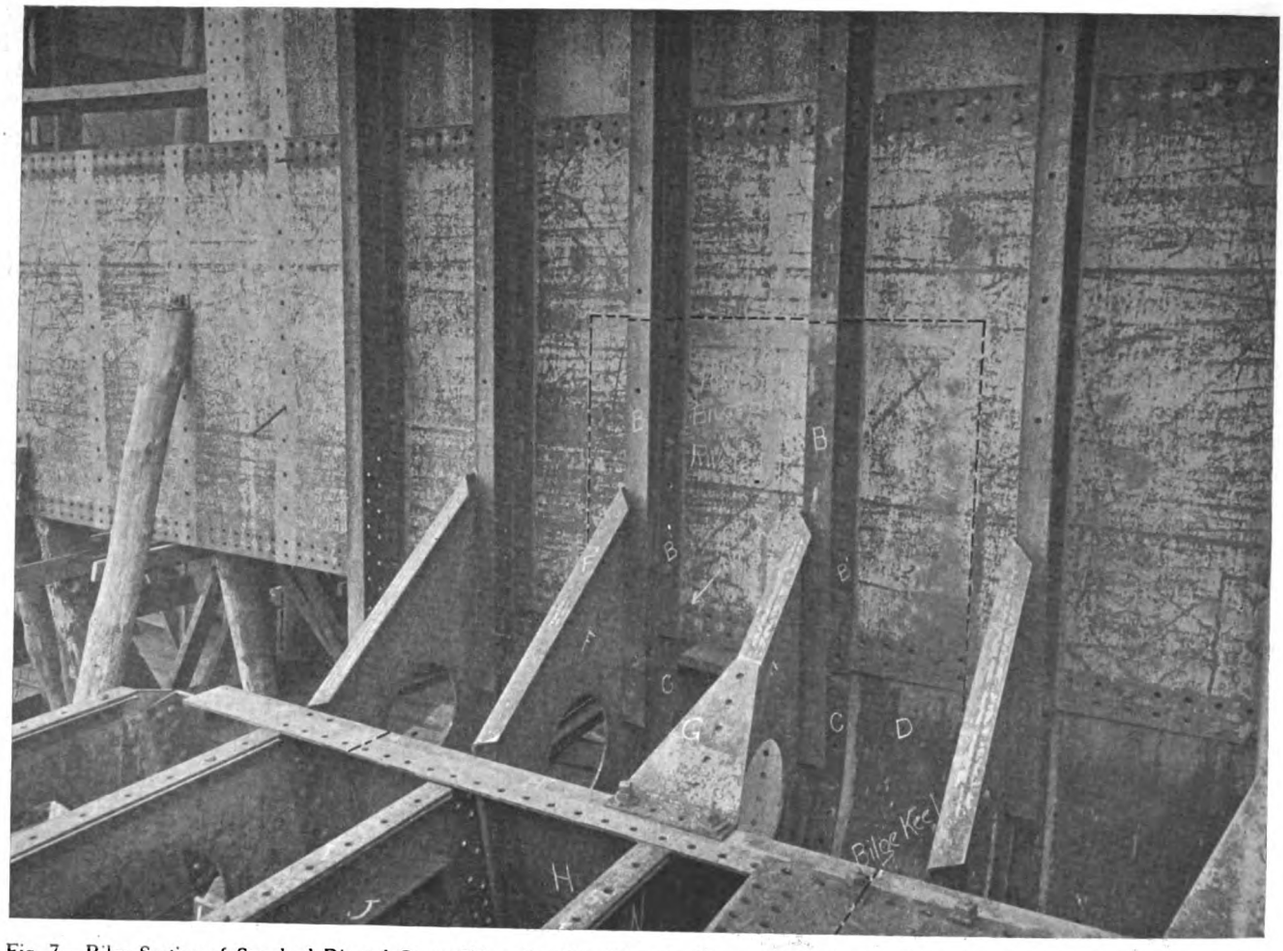

Fig. 7.—Bilge Section of Standard Riveted Cargo Ship. See Fig. 8 for Duplicate of This Section, Reproduced as an All-Welded Structure

attained may be taken as indicative of what may be expected of a vessel wholly fabricated by welding.

Because of the badly twisted and buckled condition of the plating and framing supplied for the job, the work of assembling was considerably handicapped. Some idea of this may be obtained from the photograph (Fig. 2) of the keel plates as laid on April 19, 1917. The other view of the keel plating and longitudinals (Fig. 3) as of April 22, 1917, shows how completely the buckled condition was eliminated, and by reference to the port side views of the finished centerline bulkhead (Figs. 4 and 5) it will be noted that all framing and plating was brought up perfectly true and square.

Incidentally, it may be stated also that this condition was quickly and easily attained without punching or drilling a single hole in either plating or framing.

From the above and various contemporary welding operations, the writer draws the following conclusions as to the results which may be regularly attained by conscientious, intelligent operators:

First, straight work may be made out of very badly bent and twisted plates and channels.

Second, thin plates of large area may be welded without a warp or buckle.

Third, tight joints, metal solid against metal, may be obtained without punching a single hole for holding bolts.

Fourth, work may be finished absolutely square and true to chalk line or straight edge.

Fifth, feature No. 3 may be accomplished with less than one-half the expenditure of time and materials required for previous methods of assembling work.

The table of relative costs (Table I) is appended to illustrate the saving which could have been effected by electrically welding the entire barge structure. All figures

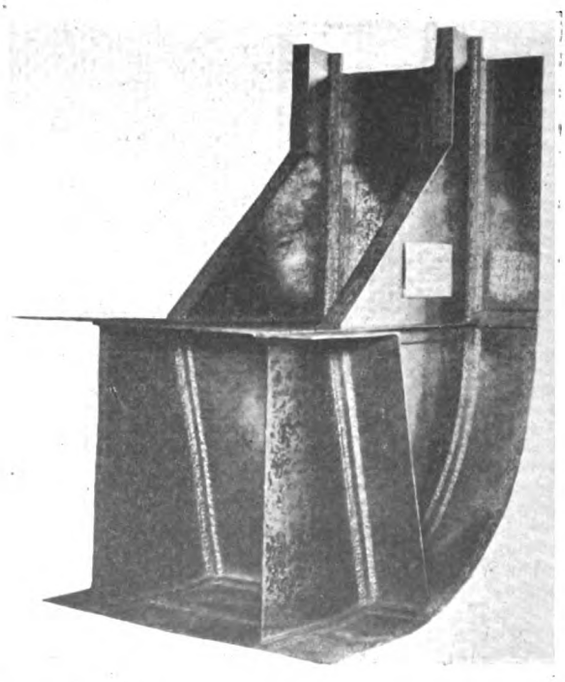

Fig. 8.—Quarter View of Bilge Section of Rivetless Cargo Ship

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in the first column were pro-rated from actual book accounts of the cost of constructing three barges of similar size and type, while those in the second column were developed from the actual cost account of welded work on the 60-foot section above described.

TABLE I.—ESTIMATED CONSTRUCTION COST OF 166-FOOT BY 39-FOOT BY 8-FOOT 8-INCH BARGE.
Based on 1917 Wage Rates and Material Prices

	Items	Riveted Design **	Welded Type
A	Plate Fitters	$1,236.00	$618.00
B	Punching and Shearing	1,045.00	522.00
C	Countersinking and Reaming	976.00	0.00
D	Riveting	3,427.00	0.00
E	Chipping and Calking	523.00	265.00
F	Smithwork	557.00	275.00
G	Erection and Assembling	2,010.00	1,320.00
H	Electric Power	382.00*	95.00*
I	Foreman	360.00	360.00
J	Plant—Special Equipment	0.00	300.00
K	Superintendence	0.00	900.00
L	Rivets	780.00	0.00
M	Liners	142.00	0.00
N	Shed and Shoring Lumber	0.00	145.00
O	Electric Welding—Including "Tacking" 51,300 feet Single Fillet— Welders—6,000 hours at 60 cents $3,600 Current—6,000 x 5 = 30,000 K. W. H. at 2½ cents 750 Wire—7,200 lbs. at 6½ cents 450	$4,800	0.00	4,800.00
P	Incidentals and Profit		0.00	1,838.00
Q	Total		$11,438.00	$11,438.00

* Current used for lighting, punching, shearing and air compressors only. Current for welding covered in Item "O".
** All figures for riveted design based on actual book cost of three barges completed during preceding month.

TABLE II.—COMPARATIVE DETAILS OF RIVETED AND RIVETLESS SHIP STRUCTURES DEVELOPED BY MEASUREMENTS OF ACTUAL BILGE SECTIONS (ILLUSTRATED BY APPENDED PHOTOGRAPHS)

Ref.	Particulars	Riveted	Welded
A	Weight of Plates required	2488 Lbs.	1884 Lbs.
B	Weight of Angles, Beams and Channels	764 Lbs.	194 Lbs.
C	Weight of Straight Bars	none	360 Lbs.
D	No. of ⅞-inch Rivets	48	none
E	No. of ¾-inch Rivets	231	none
F	No. of ⅝-inch Rivets	108	none
G	Total Number of Rivets	387	none
H	Total Weight of Rivets	200	none
I	Number of Liners required	4	none
J	Weight of Liners	31 Lbs.	none
K	Weight of Weld Material added	none	120 Lbs.
L	Total weight of complete section	3,483 Lbs.	2,558 Lbs.
M	Lineal Feet of Heavy Flanging and Shaping	22	none
N	Square Feet of Forge Shaped Bilge Plate	24	none
O	Square Feet of Machine Rolled Bilge Plate	none	20
P	Number Lineal feet of Welds in terms of ¼ square inch section	none	620
Q	Number Lineal feet of Calked Edges	57	none
R	Total Number of all Rivet Holes in Section	826	none
S	Average Area of Plates of full size	17,280 sq. in.	15,235 sq. in.
T	Average Number of Rivet Holes in same	550	none
U	Average Area of Rivet Holes in same	431.97 in.	none
V	Reduction of Plate Area due to Punching	2½%	none
W	Typical Number of holes in Rows across Plate	15	none
X	Average Total Diameter of Rows across Plate	15%	none
Y	Average Proportion of Hole Diameter to Plate	25%	none

NOTE:—
1. Above includes no allowance for bilge keel.
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3. Difference in weights given in item "A" due to butting plate edges for welding instead of using lapped seams for riveting.

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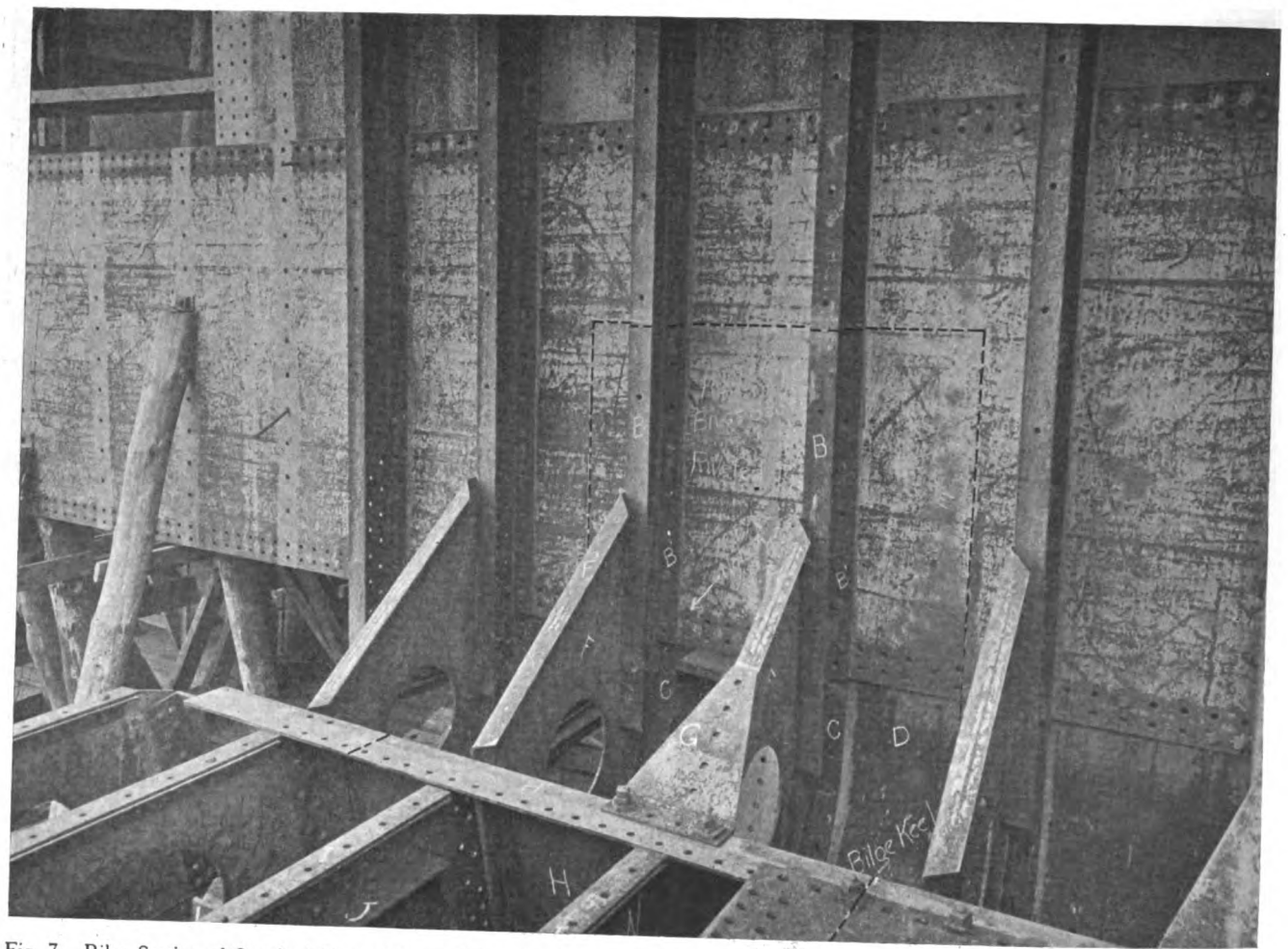

Fig. 7.—Bilge Section of Standard Riveted Cargo Ship. See Fig. 8 for Duplicate of This Section, Reproduced as an All-Welded Structure

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Incidentally, it may be stated also that this condition was quickly and easily attained without punching or drilling a single hole in either plating or framing.

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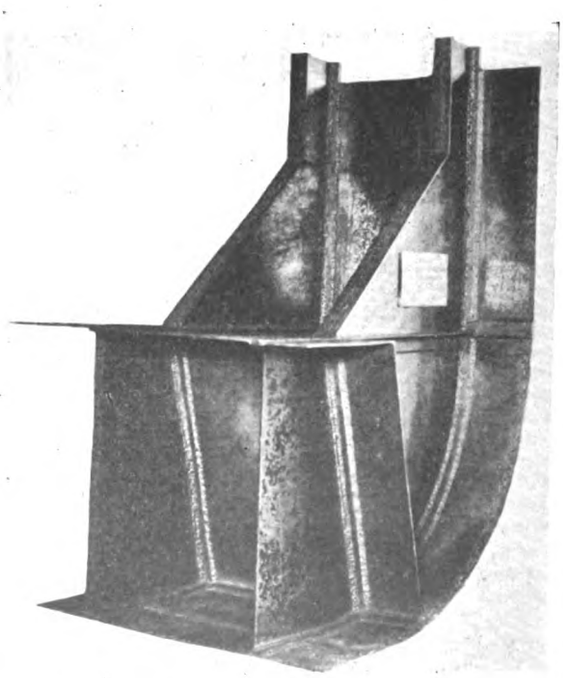

Fig. 8.—Quarter View of Bilge Section of Rivetless Cargo Ship

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TABLE I.—ESTIMATED CONSTRUCTION COST OF 166-FOOT BY 39-FOOT BY 8-FOOT 8-INCH BARGE.
Based on 1917 Wage Rates and Material Prices

	Items		Riveted Design **	Welded Type
A	Plate Fitters		$1,236.00	$618.00
B	Punching and Shearing		1,045.00	522.00
C	Countersinking and Reaming		976.00	0.00
D	Riveting		3,427.00	0.00
E	Chipping and Calking		523.00	265.00
F	Smithwork		557.00	275.00
G	Erection and Assembling		2,010.00	1,320.00
H	Electric Power		382.00*	95.00*
I	Foreman		360.00	360.00
J	Plant—Special Equipment		0.00	300.00
K	Superintendence		0.00	900.00
L	Rivets		780.00	0.00
M	Liners		142.00	0.00
N	Shed and Shoring Lumber		0.00	145.00
O	Electric Welding—Including "Tacking" 51,300 feet Single Fillet—			
	Welders—6,000 hours at 60 cents	$3,600		
	Current—6,000 x 5=30,000 K. W. H. at 2½ cents	750		
	Wire—7,200 lbs. at 6½ cents	450		
		$4,800	0.00	4,800.00
P	Incidentals and Profit		0.00	1,838.00
Q	Total		$11,438.00	$11,438.00

* Current used for lighting, punching, shearing and air compressors only. Current for welding covered in Item "O".
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TABLE II.—COMPARATIVE DETAILS OF RIVETED AND RIVETLESS SHIP STRUCTURES DEVELOPED BY MEASUREMENTS OF ACTUAL BILGE SECTIONS (ILLUSTRATED BY APPENDED PHOTOGRAPHS)

Ref.	Particulars	Riveted	Welded
A	Weight of Plates required	2488 Lbs.	1884 Lbs.
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G	Total Number of Rivets	387	none
H	Total Weight of Rivets	200	none
I	Number of Liners required	4	none
J	Weight of Liners	31 Lbs.	none
K	Weight of Weld Material added	none	120 Lbs.
L	Total weight of complete section	3,483 Lbs.	2,558 Lbs.
M	Lineal Feet of Heavy Flanging and Shaping	22	none
N	Square Feet of Forge Shaped Bilge Plate	24	none
O	Square Feet of Machine Rolled Bilge Plate	none	20
P	Number Lineal feet of Welds in terms of ¼ square inch section	none	620
Q	Number Lineal feet of Calked Edges	57	none
R	Total Number of all Rivet Holes in Section	826	none
S	Average Area of Plates of full size	17,280 sq. in.	15,235 sq. in.
T	Average Number of Rivet Holes in same	550	none
U	Average Area of Rivet Holes in same	431.97 in.	none
V	Reduction of Plate Area due to Punching	2½%	none
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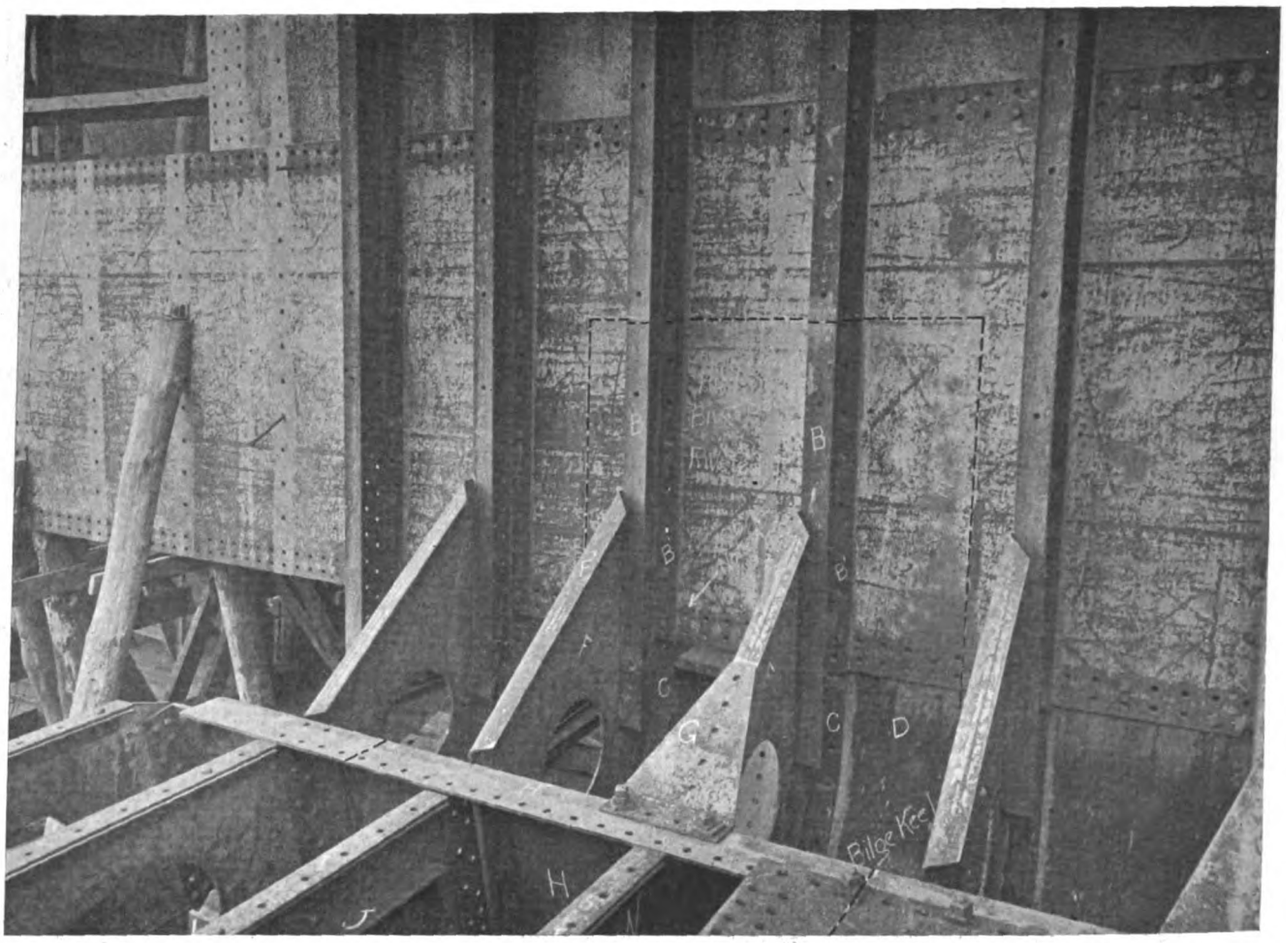

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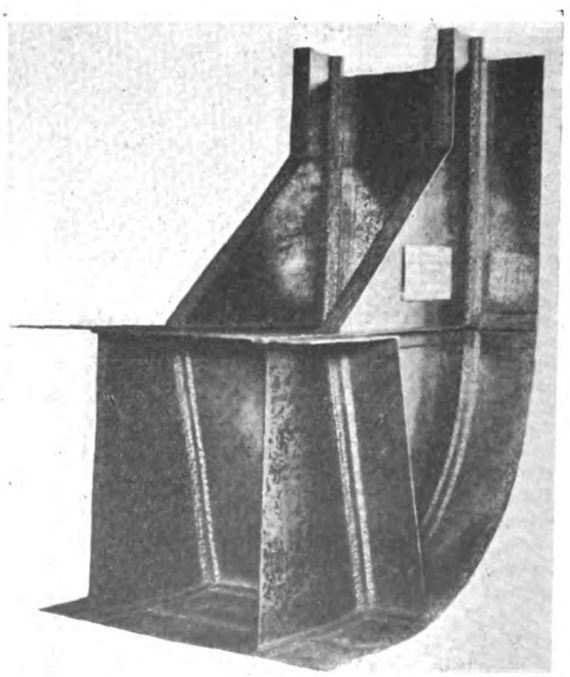

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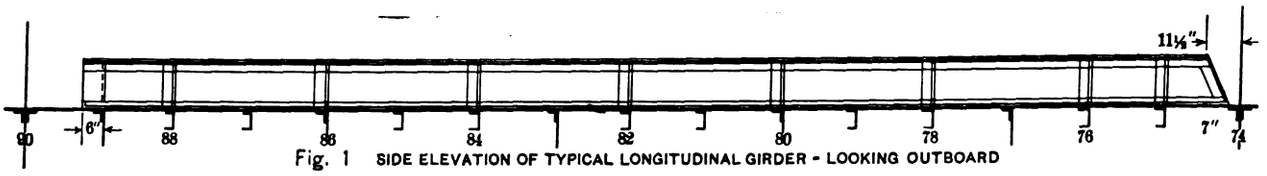

Fig. 1 SIDE ELEVATION OF TYPICAL LONGITUDINAL GIRDER - LOOKING OUTBOARD

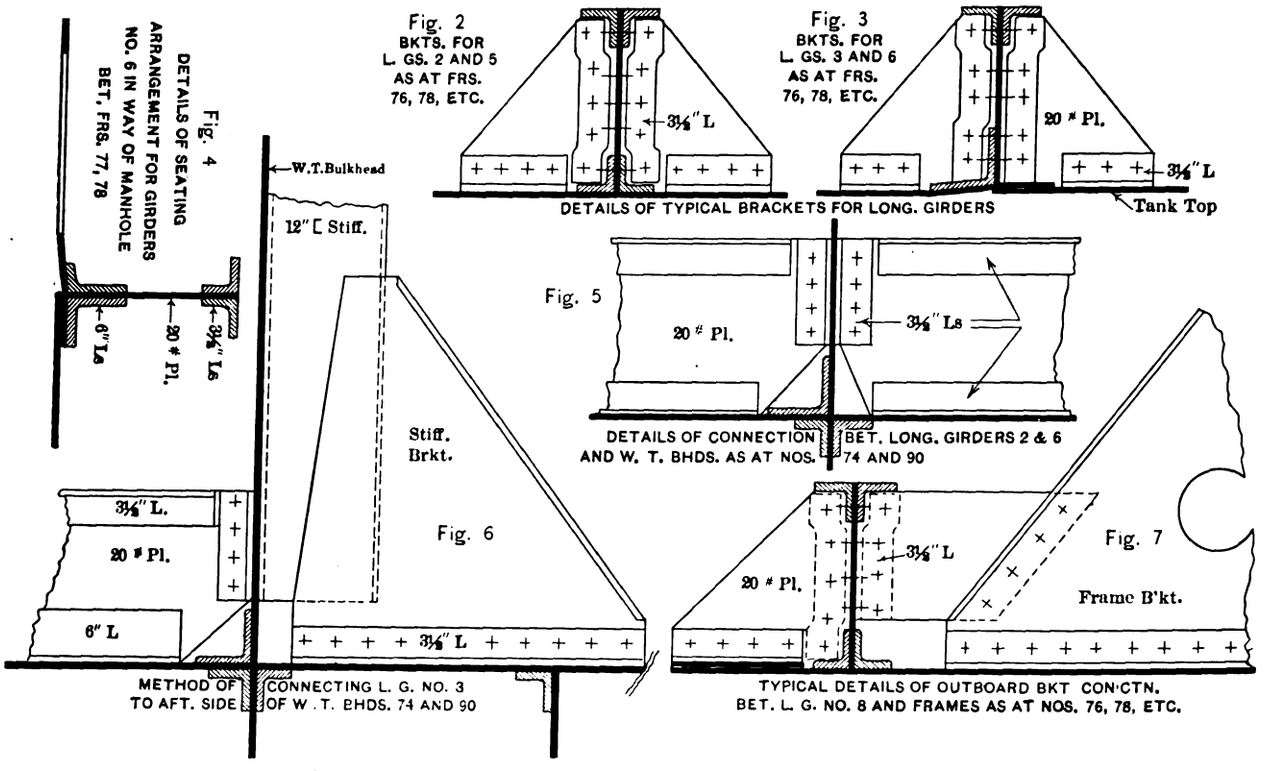
Fig. 2
BKTS. FOR L. GS. 2 AND 5 AS AT FRS. 76, 78, ETC.
3½" L
Fig. 3
BKTS. FOR L. GS. 3 AND 6 AS AT FRS. 76, 78, ETC.
20 # Pl.
3½" L
Tank Top
DETAILS OF TYPICAL BRACKETS FOR LONG. GIRDERS
Fig. 4
DETAILS OF SEATING ARRANGEMENT FOR GIRDERS NO. 6 IN WAY OF MANHOLE BET. FRS. 77, 78
6" Ls
20 # Pl.
3½" Ls
W.T.Bulkhead
12" [Stiff.
Fig. 5
20 # Pl.
3½" Ls
DETAILS OF CONNECTION BET. LONG. GIRDERS 2 & 6 AND W. T. BHDS. AS AT NOS. 74 AND 90
Stiff. Brkt.
Fig. 6
3½" L.
20 # Pl.
6" L
3½" L
METHOD OF CONNECTING L. G. NO. 3 TO AFT. SIDE OF W. T. BHDS. 74 AND 90
Fig. 7
20 # Pl.
3½" L
Frame B'kt.
TYPICAL DETAILS OF OUTBOARD BKT CONCTN. BET. L. G. NO. 8 AND FRAMES AS AT NOS. 76, 78, ETC.

Plate 1.—Essential Details of Riveted Oil Tank Foundations for 12,000-Ton Cargo Ships

bulkhead stiffener brackets, to which they are rigidly attached as by butt welds.

Each welded girder consists of a superimposed T-section (see Plate 5) with the bottom edge of the web member butt welded to the top edge of a series of plates of trapezoidal shape. This augmented section is further combined with the tank top plating by "butt to top surface" welds over each floor, thereby forming a plate girder of great rigidity and strength.

There is provided also a series of transverse girders (see Plates 2 and 3) disposed as intercostals between the several rows of longitudinal girders, the whole being welded to each other and to the tank top as a homogeneous unit structure extending over the entire fore and aft length of holds 4 and 5 and to and between the port and starboard frames.

As a final addition to the rigidity and strength of foundations, there is provided at each midway point between the intercostal girder connections to longitudinals a pair of brackets which are fitted to the girder and tank top and "butt to side" welded, as shown in half section on Plate 5. Fig. 7 on Plate 4 (compare Fig. 7 on Plate 1) illustrates the base connection between the outboard longitudinals (girder 8) and the ship's framing, in line with each transverse girder.

In point of time is is possible to complete such structures much more quickly than by riveting, provided a sufficient number of welders are employed. Approximately five welders and machines would be engaged for 26 working days of 8 hours each to complete the one-quarter unit shown in the sketches; but if 40 or more welders were employed, the entire foundations for holds 4 and 5 could be finished in 13 days or less.

Moreover, it must be patent to all that the material could be prepared for installation very quickly, because of the fabricating operations being limited to shearing the plates for girders and brackets. Of these there would be required a total of 225 plates, all but one of which are 11 inches wide, of short lengths and similar shapes (see template sheets Nos. 6 and 7).

It is a generally recognized fact that for each department dealing with the fabrication of an article, no matter how small a part it may have in the production of that article, allowance must be made for the overhead cost of routing the job and supervising its passage through said department. Obviously, the fewer the operations required for the fabrication of an article, and, per se, the fewer departments there are contributing to its production, the less it will cost in time, transportation and overhead.

From records of similar undertakings, information developed in the construction of foundations for ships now building, and by estimating the costs of labor and material required as indicated in the drawings, it is expected that the two types of foundations will closely approximate the unit totals tabulated in the schedule of comparative costs (see Table III). In this table the figures for riveted type foundations were developed by the shipyard's estimating department.

In justice to the claims of welded construction, and by way of protesting the customary method of estimating costs by adding some predetermined percentage for overhead, it is contended that the respective amounts, $150

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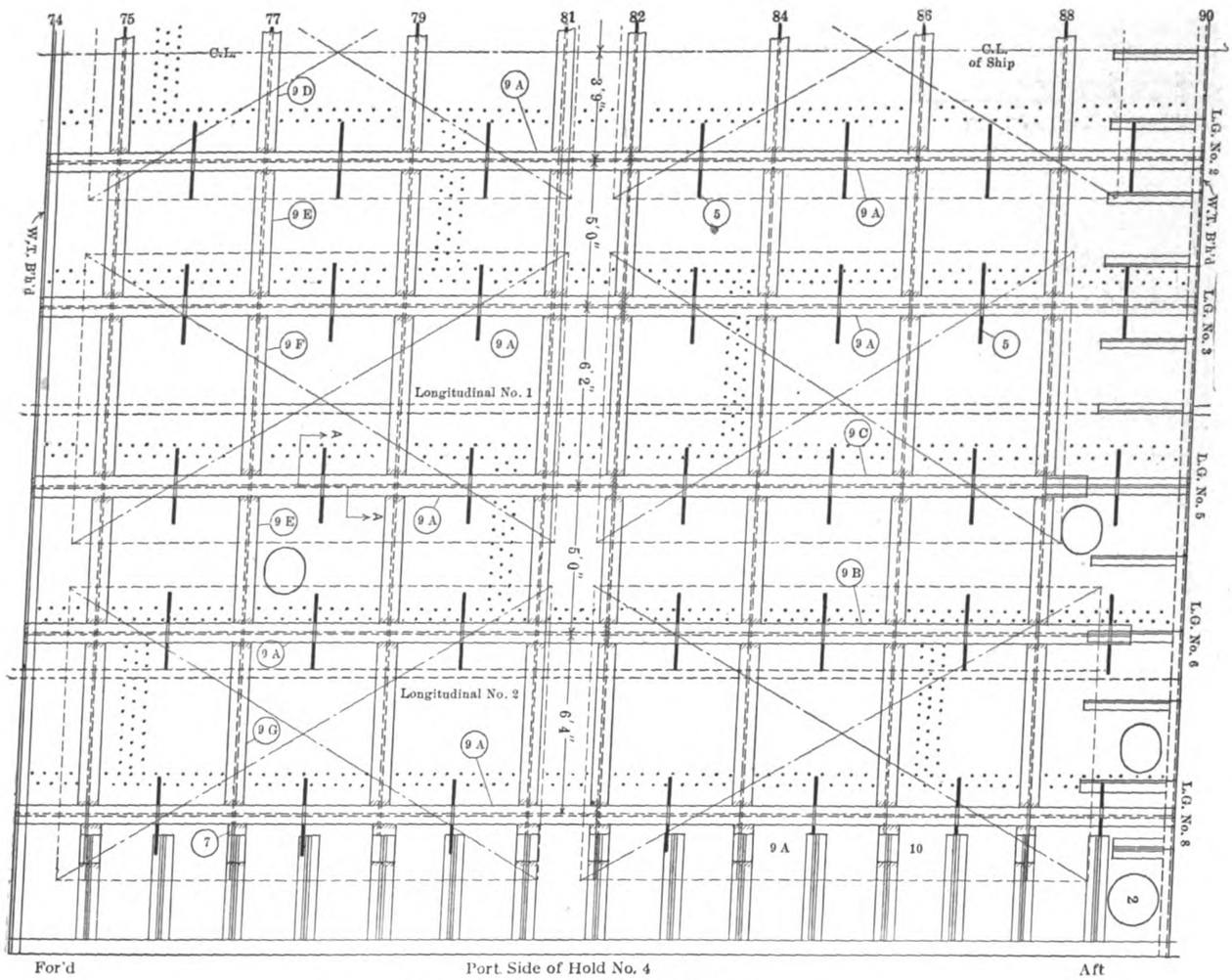

Plate 2.—Plan of Welded Foundations

and $50, for supervision and power required in connection with the riveted type foundations, (see items 19 and 20) are pure guesswork. As a matter of fact, the results thus far reported on these jobs indicate that both will greatly exceed the figures used.

One of the very attractive features of welded construction is its freedom from uncertainty in the matter of costs. Not alone does it permit the absolute elimination of numerous fabricating operations, but the exceeding simplicity of the welding method and the certain fixed relation which its power, material and labor input bears to the fabricated product, enable the estimator to provide advance cost schedules which may be depended upon as closely approximixating 100 percent correct. With the sure approach of keen competition in ship construction, the successful yard must discontinue the present practice of "lumping" the cost of all operations of uncertain analysis into the "overhead" account. There is no question as to the unfairness of handicapping what might otherwise be a very profitable undertaking by adding an abnormal overhead simply because it happens to be carried out in the same yard with other jobs of similar character but loaded with numerous costly operations and expensive supervision.

While admitting the undoubted strength of riveted girder foundations to meet the stress of ordinary heavy seas, it is believed the surging content of one or more partly filled tanks rigidly attached to such girders will some day destroy the oil-tightness of the inner bottom. By calculation there are over 5,600 rivets driven through the tank top for securing the girders in the two holds, hence the possibility of trouble from this source is just 5,600 times that due to damage to electrically welded foundations, since the latter do not require a single perforation in the tank top.

By reference to Fig. 2 on Plate 5 it will be noted that the base section at the point of contact between the girder and tank top is in the form of a +, the spread of which is sufficient to provide great structural rigidity and yet the metal is thin enough to permit cutting away the entire foundation structure and chipping off any roughness remaining on the tank top when the oil tanks must give way for enlargement of cargo space.

In view of such possibility it would be a matter of very grave concern to the owners to contemplate the cost and delay incident to the removal of riveted foundations with 5,600 rivets to be cut out, 5,600 holes in the tank top to be refilled and made oil-tight, tanks retested and the ship otherwise restored to its original condition. As in the original installation, *with a welded structure there would be no perforation of the tank top, and, consequently, no necessity for retesting the inner bottom tanks.*

As a weight-supporting structure the welded foundations above described possess the advantage of ample bearings at all critical points, and the intercostal arrangement of girders insures a most efficient form of longitudinal and transverse bracing.

From an economical standpoint, welded construction

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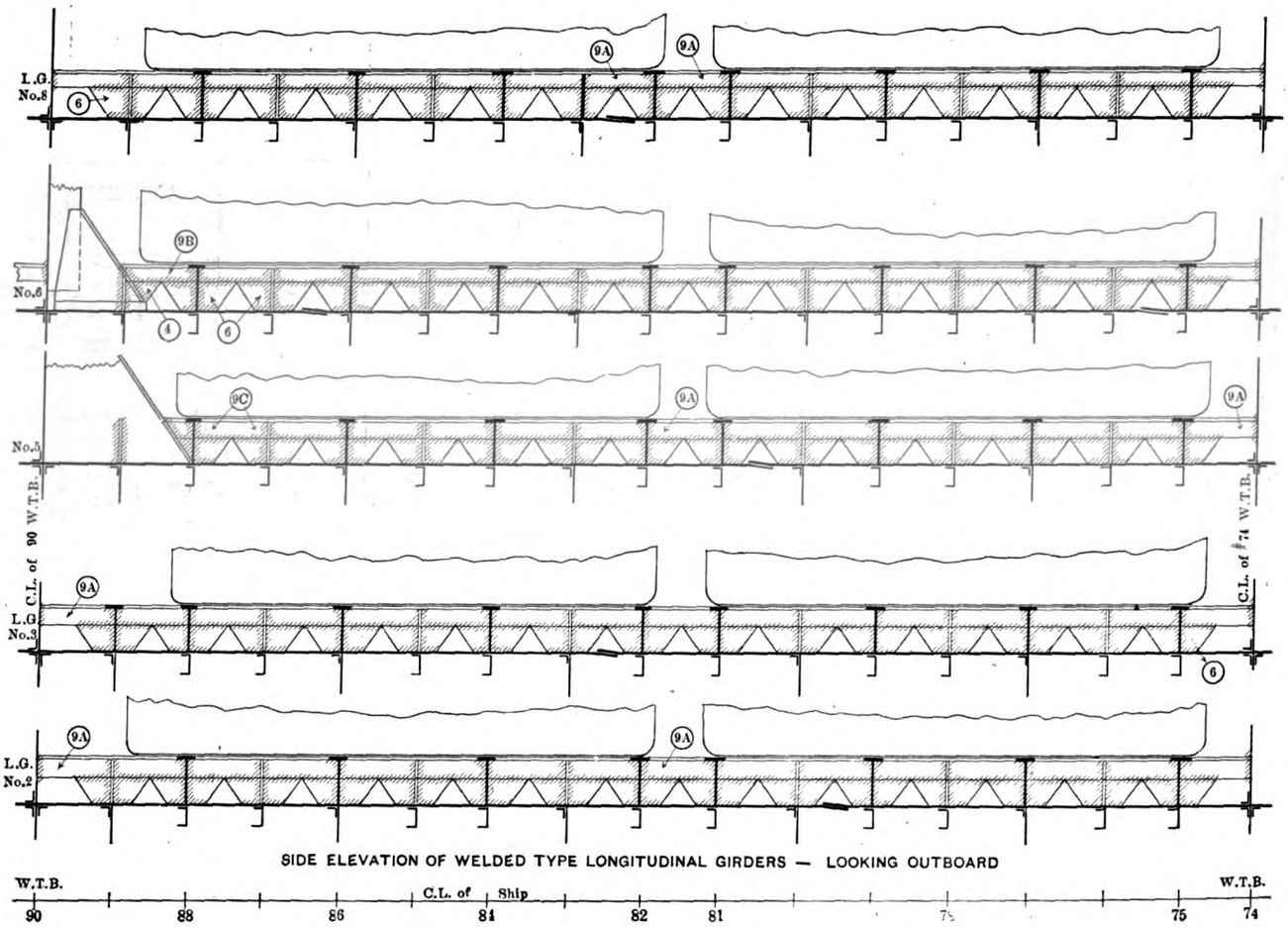

Plate 3.—Welded Type Longitudinal Girders

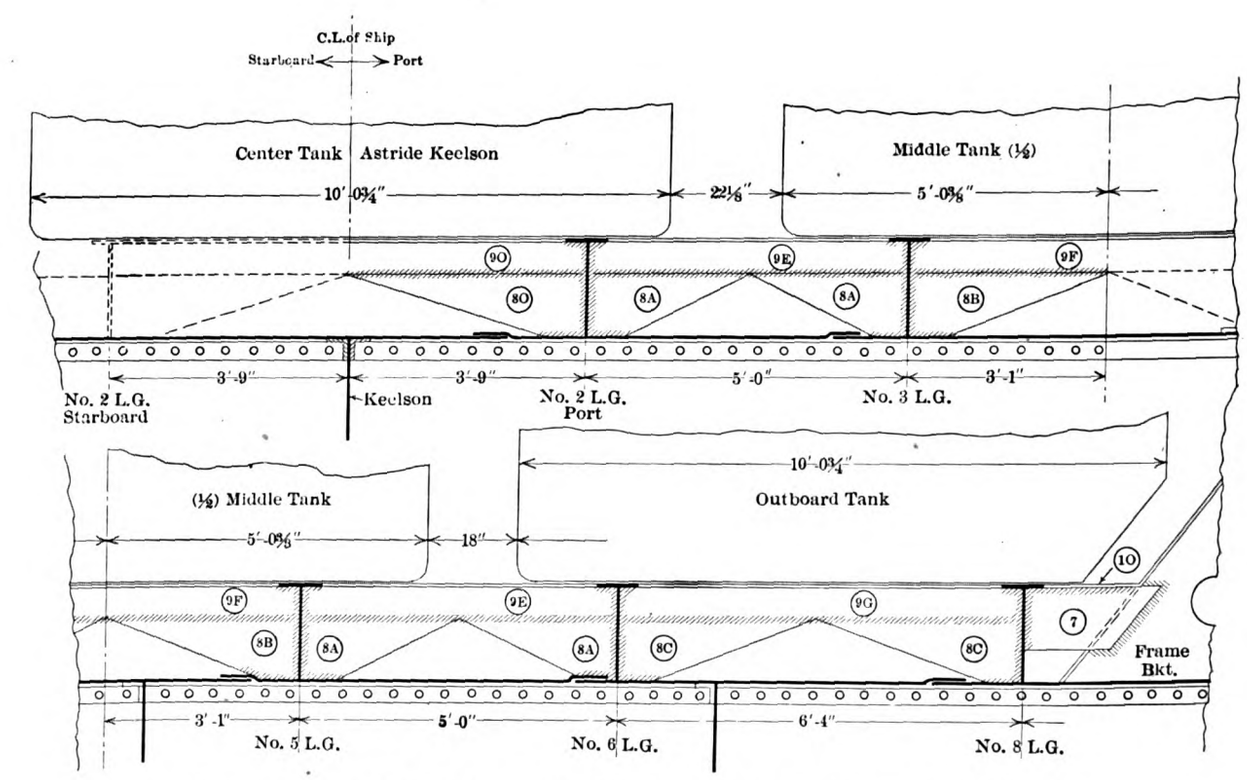

Plate 4.—Elevation of Typical Intercostal Girder, as on Floor No. 77, Hold No. 4, Looking Aft

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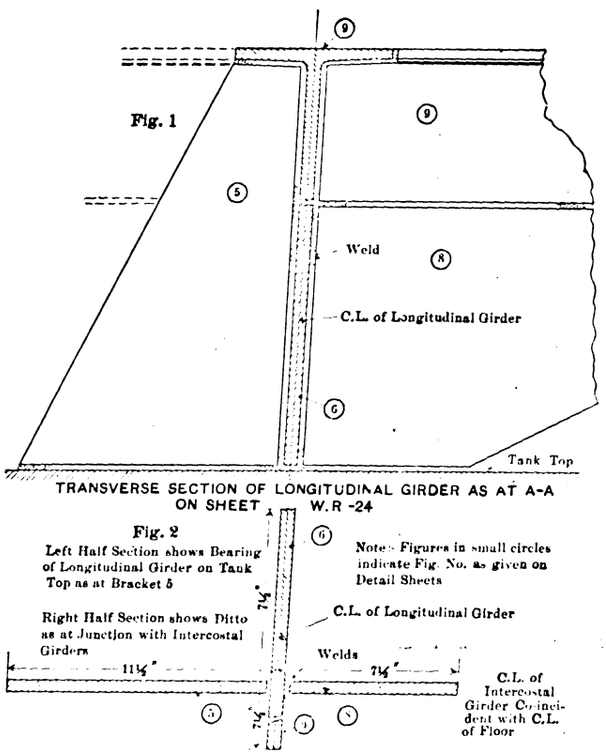
Fig. 1
Weld
C.L. of Longitudinal Girder
Tank Top
TRANSVERSE SECTION OF LONGITUDINAL GIRDER AS AT A-A ON SHEET W.R -24
Fig. 2
Left Half Section shows Bearing of Longitudinal Girder on Tank Top as at Bracket 5
Right Half Section shows Ditto as at Junction with Intercostal Girders
Notes Figures in small circles indicate Fig. No. as given on Detail Sheets
C.L. of Longitudinal Girder
Welds
C.L. of Intercostal Girder Coincident with C.L. of Floor

Plate 5.—Sections of Longitudinal Girder

has the advantage of permitting the utilization of scrap material in many places. By enlargement of the weld section any joint may be made to exceed the virgin plate in strength, hence "piecing" may be followed to the complete elimination of the scrap pile except where objection is made to the appearance of seams.

As a matter of interest to the shipowner, the saving in weight of structure, with no diminution of strength or safety, means lower initial costs, and, most important of all, greater operating returns. Since each pound reduction in weight of ship permits carrying another pound of cargo, the weight reduction obtainable by adopting welded foundations for oil tanks would permit loading *more than* 10 *tons additional cargo each voyage* without affecting the speed or sailing cost. And, what is true of the constructive and operating features, hereinabove mentioned, is likewise applicable to practically every detail of the ship's structure.

Examples of Welded Ships

That the reader's interest may be satisfied by a near complete record of the more important undertakings in the line of electrically welded vessel construction, reference will now be made to one other American boat and to those built in foreign countries which have received official sanction and more or less attention by the technical press.

It should not, however, be understood that the examples referred to represent the full extent to which electric welding is now employed in ship construction. As an indication of the more extended application of welding to the fabrication of ships' parts, the reader's attention is invited to the schedules of permissible welding now authorized by the United States Navy and the classification societies, as featured elsewhere in the present issue of this journal.

A Welded Motorboat

The welded motorboat *Dorothea M. Geary* was built by the Geary Boiler Works and launched at Ashtabula, Ohio, about December 1, 1915. Her dimensions are: Length, 42 feet; beam, 11 feet; depth, molded, 6 feet 6 inches; draft, 3 feet 4 inches. Her frames are 1½-inch by 1½-

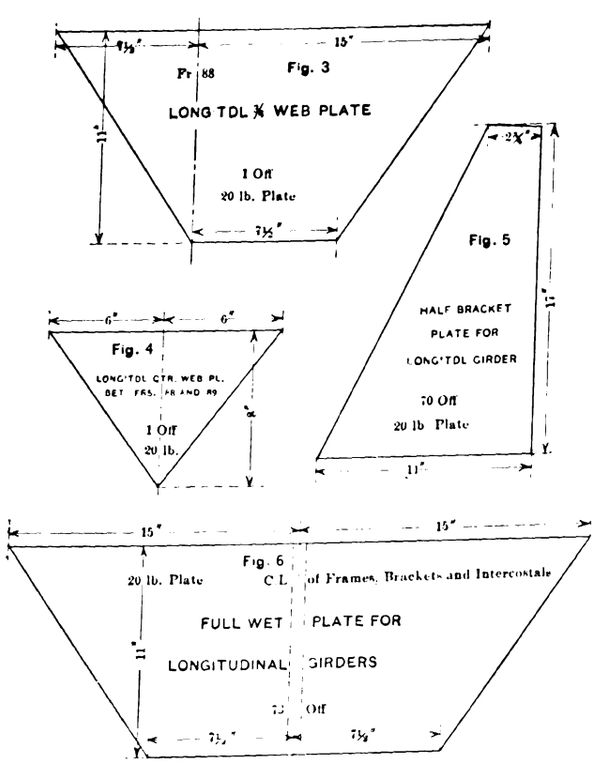

Plate 6

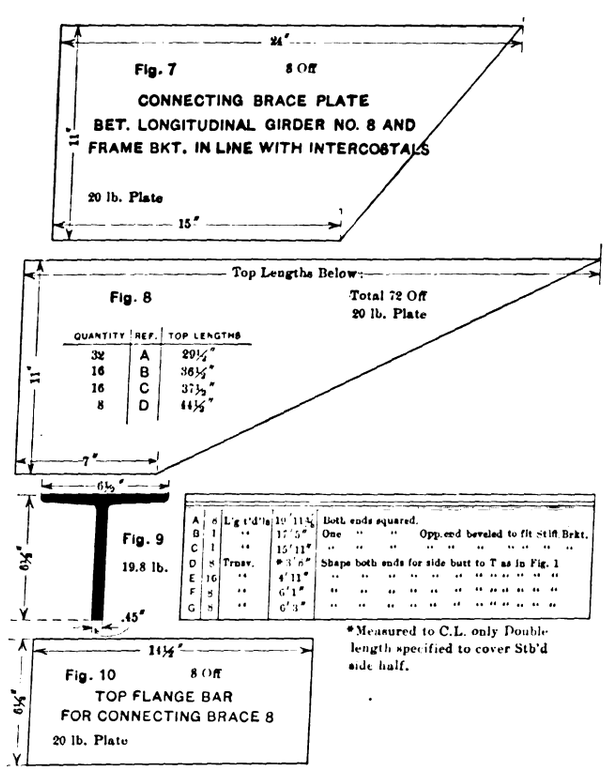
Fig. 7
8 Off
CONNECTING BRACE PLATE BET. LONGITUDINAL GIRDER NO. 8 AND FRAME BKT. IN LINE WITH INTERCOSTALS
20 lb. Plate
Top Lengths Below:-
Fig. 8
Total 72 Off
20 lb. Plate
QUANTITY REF. TOP LENGTHS
32 A 20½"
16 B 36½"
16 C 37½"
8 D 44½"
Fig. 9
19.8 lb.
Both ends squared.
One " " Opp. end beveled to fit Stiff Brkt.
Shape both ends for side butt to T as in Fig. 1
*Measured to C.L. only Double length specified to cover Stb'd side half.
Fig. 10
8 Off
TOP FLANGE BAR FOR CONNECTING BRACE 8
20 lb. Plate

Plate 7

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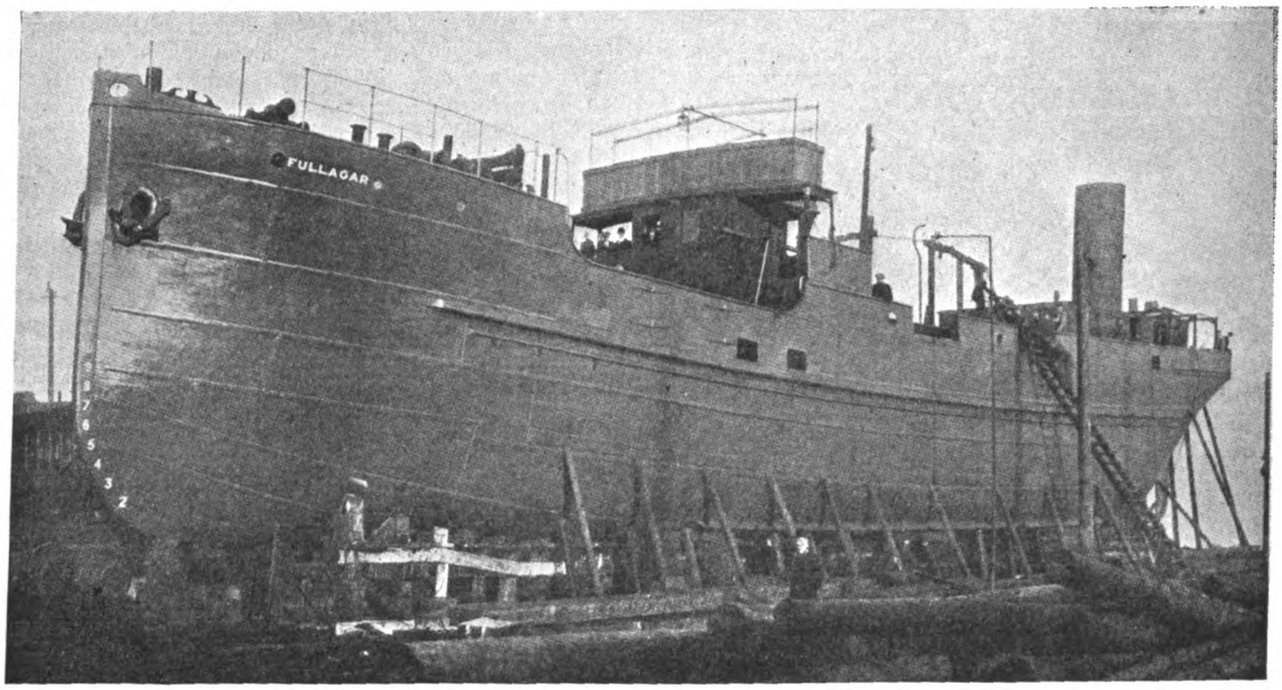

Fig. 9.—Electrically-Welded Coaster *Fullagar*, Built by Cammell Laird & Company, Ltd., Under the Quasi-Arc Welding Patents

inch by 1¼-inch angles, spaced 18 inches between centers; while her hull and deck plating are made of No. 8 steel in 4-foot by 8-foot and 4-foot by 10-foot sheets.

The keel, frames and deck house were riveted, while the hull and fore and aft deck plates were electrically butt welded to each other. Where the jointure occurred between frames or other suitable landing, the butt was reinforced by a backing strap.

Although unaccustomed to marine construction the builders completed the *Geary* in about 80 days, and have since continued to operate her as a floating repair boat in and about Ashtabula harbor. In the meantime the only difficulties experienced have been leaky rivet joints caused by ice jams and collisions, and these were quickly repaired by welding.

The Germans have been doing a great deal of electric welding on many of their ships, as evidenced by post-war inspections of the *Deutschland* and other submarines captured by the British fleet. No extended information regarding the German operations is as yet obtainable, however, but when known their methods will undoubtedly add much to our ethnology of welding.

British Welded Ships

It is to the English builders that we must doff our caps for persistent research and accomplishment in the line of electrically welded ship construction. Although relatively much smaller than our partly constructed American exhibits, and of later date, they have already produced two welded vessels which are worthy of special mention in any history of shipbuilding.

The first of these is the 200 deadweight-ton electrically welded cross channel towing barge, built at Richborough, and launched in May, 1918. Her dimensions are: Length between perpendiculars, 125 feet 9 inches; breadth, molded, 16 feet 4 inches; depth, molded, 7 feet 9 inches. In general, the middle portion of this barge is of rectangular cross section with curved bilges, deck curved stem, transom stern and two hatchways each 42 feet by 10 feet. She is provided with one fore and aft and one midship watertight bulkhead.

All plating and framing was assembled with service bolts, spaced 10½ inches between centers, which were afterwards removed and the holes filled with plugs and welded up flush. When completed, the barge was energetically employed, along with many others of similar type but riveted, in the transportation of ammunition between English and French ports, and, aside from occasional leakage through the plugged service bolt holes, has given excellent satisfaction.

The second example of English enterprise is the 500 deadweight-ton coasting steamer *Fullagar*, launched on February 5, 1920, at the Birkenhead yards of Messrs. Cammell, Laird & Company, Ltd. A side view of this ship is shown in Fig. 9.

The *Fullagar* is a single deck vessel with superimposed bridge and pilot house structure, and is fitted with the Fullagar-Diesel type engines. She is, to all intents and purposes, a completely welded ship, although the more or less extended use of tack and service bolts in the assembly of her frames and plating detracts somewhat from the possible advantage of electrically welded vessels erected without perforating any of the watertight members.

The particular purport of this paper has been to feature the simplifying effect of substituting welding for riveting in the construction of ships, as also the saving of weight and costs, by a few illustrations which may be accepted as typical of many other applications of that method of construction ashore and afloat.

If one were to calculate the number of square feet of shop floor space required per ton of ships' plates fabricated by the riveting process, likewise the number and cost of tools required, and compare the results with those required per ton of plates fabricated by the arc welding system, the showing would be almost unbelievable. Nevertheless, it may be safely predicted that the time is near when the equipment of a ships' plate fabricating shop will be practically limited to shears, rolls and welding generators. The only punches required will be those used for making the welding assembler's jigs, and we shall also have a few chippers and grinders for surfacing the finished welds.

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TABLE III.—COMPARATIVE COSTS OF RIVETED AND WELDED OIL TANK FOUNDATIONS FOR 12,000 TON CARGO SHIPS.
Figure for Port Side of Hold No. 4 or ¼ of Complete Foundation

Ref. No.	Distribution	Riveted Construction		Welded Construction	
1	Drawings		$50.00		$30.00
2	Template Work		150.00		30.00
3	Ship Fitters and Laying Out				40.00
4	Plate, Tee and Angle Shearing				46.80
5	Forge and Press Work		150.00	none	.....
6	Planing			none	.....
7	Punching			none	.....
8	Drilling and Reaming			none	.....
9	Countersinking			none	.....
10	Rigging			none	.....
11	Assembling, Erecting, Regulating and Bolting				14.00
12	Riveting				35.00
13	Gas Cutting		802.00	none	.....
14	Packing and Leading				15.00
15	Chipping and Calking			none	.....
16	Tank Testing				15.00
17	Welding: Incl. Power and Labor			none	.....
18	Painting, Omit, as same for both	none	.....		1,310.35
19	Add Quarterman separately for Riveting		.....		.....
20	Add Power separately for Riveting		150.00	See No. 17	.....
			50.00	See No. 17	.....
21	Total Labor Cost		*1,352.00		1,536.15

	Materials Required	Net Weight	Cost	Net Weight	Cost
22	Plate for Girders and Brackets	7730	248.46	6004	200.00
23	Angles for Girders and Brackets	10480	308.94	none	.....
24	Tees for Girders and Intercostals	none	.....	7821	248.70
25	Rivets, Figured as 4,000 at ½ lb. ea. for Heads*	2000	200.10	none	.....
26	Welding Wire	none	.....	1175	94.00
27	Total Materials	20210	757.50	15000	542.70
28	Grand Total, Labor and Materials	20210	2,109.50	15000	2,078.85

* Item 21 for Riveted Work was considerably increased by unexpected incidentals.

At the construction end we will require crane service and shoring for erection, but the work will be assembled, regulated and drawn to place absolutely equal to or better than the present "bolting up" system, *without a single perforation in the plating*, and with much less expenditure of time and materials.

This is no fanciful dream. It is perfectly feasible, and has been proven commercially successful. All one needs is to know how, and exercise sufficient ingenuity to improvise a method of dealing with each new condition as it arises. In this respect scientific welded construction is not one whit different from the successful bolter-up's method. It differs only in speed, cost and convenience.

It is not claimed that the actual welding of plating joints is more rapid or less expensive than riveting, but, considered as a whole, welded construction is more rapid and less expensive than the aggregation of operations which, together, constitute riveted construction.

And, when the work is complete, note the difference. By no possible means can a riveted joint be made stronger or more durable than the plate itself. With welding it is only necessary to increase slightly the area of section to obtain a joint having 100 percent plus efficiency.

The welded ship will afford great satisfaction to the ship's crew, with its complete absence of plate edges and billowy seams. What speed and free maneuvering the skipper can report because of the ship's perfectly smooth hull, and what satisfaction to the owners that a 5,000-ton ship can actually carry 6,000 tons of cargo due to the lesser weight of material required in her construction!

The methods and policies of our ancestors were good in their day only because they utilized such means as were then available. History records that the writer's grandfather operated his woolen mill from 1815 to 1830 with yokes of oxen; but, few and inefficient as they then were, during the latter year he installed a steam engine. No method should be considered *good enough* when competition and genius have developed something greatly superior.

It is an old saying, that history often repeats itself, and the recent report of the loss of the tanker *Mielero* by breaking in two in mid-ocean is a too oft-repeated tale. One of the greatest arguments in favor of the welded ship is its freedom from the weakening effect of punching its most important strength members full of holes for rivets. In the breaking up of practically every stranded ship it may be noted that the structure first gives way along the line of riveting which connects the midship bulkhead with outside plating, a jointure which almost completely encircles the hull. The loss of strength due to perforating a plate cannot be regained, even in part, by filling the hole with a rivet. *Moral.*—For safety, economy and durability, weld the ship!

Bronze Sleeve Welded on Propeller Shaft

IN November, 1919, the Welded Products Company, of Birmingham, Ala., carried through a welding job for the Emergency Fleet Corporation that is of general interest to marine engineers, for it is apparently the first successful attempt at welding the joints of the bronze sleeves on a propeller shaft.

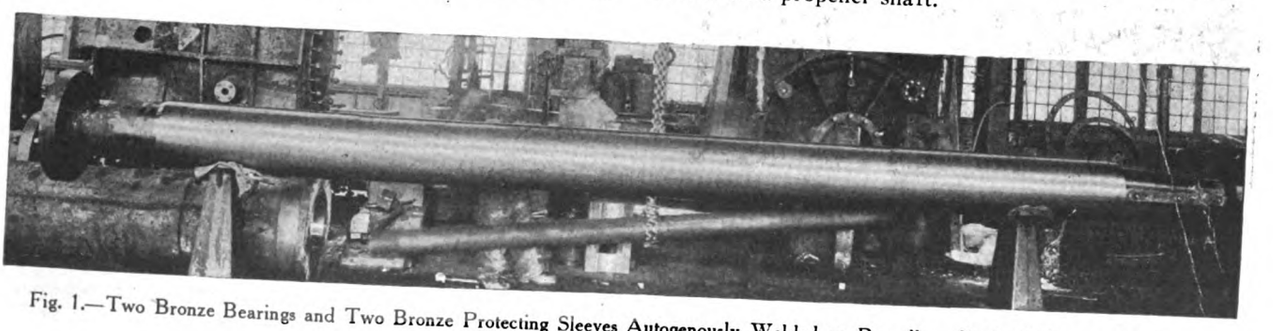

Fig. 1.—Two Bronze Bearings and Two Bronze Protecting Sleeves Autogenously Welded on Propeller Shaft, Making a One-Piece Sleeve 26 Feet in Length

In this case the shaft was 26 feet in length and had a one-piece bronze sleeve almost entirely covering it when finished. This sleeve was made up of two bearings and two sections for protecting the shaft. After the various sections had been shrunk on, the joints were autogenously welded together by means of the oxy-acetylene torch. The welding rods used were similar to composition "G" specified by the Navy Department.

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Repairing Cast Iron Cylinders by Welding

BY COMMANDER H. G. KNOX, U. S. N.,* AND JAMES W. OWENS†

In this article the authors describe how a badly fractured large high pressure marine engine cylinder was successfully repaired by means of electric arc welding. Before taking up the details of this remarkable job, however, the advantages and disadvantages of the various other forms of welding are discussed from the viewpoint of their application to this class of repair work.

THERE are three forms of welding which are more or less suitable for the welding of cast iron, namely, thermit, gas and arc, and one of the requirements of the welding engineer is to decide which form should be used. In making his decision, it is necessary to bear in mind the following:

(a) Equipment available to do the job.
(b) Time available.
(c) Nature and location of break.
(d) Where welding is to be done (on shipboard or in shop).
(e) Cost as a determining factor.
(f) Relative suitability of each form of welding to obtain strength.

Thermit Welding

As it is well known, thermit is a mixture of iron oxide and aluminum combined in the proper proportions which on ignition combines with the evolution of an enormous heat to form a superheated fluid iron with an alumina slag.

A weld is made by tapping into the mold surrounding the fractured parts, steel as made by this reaction, which

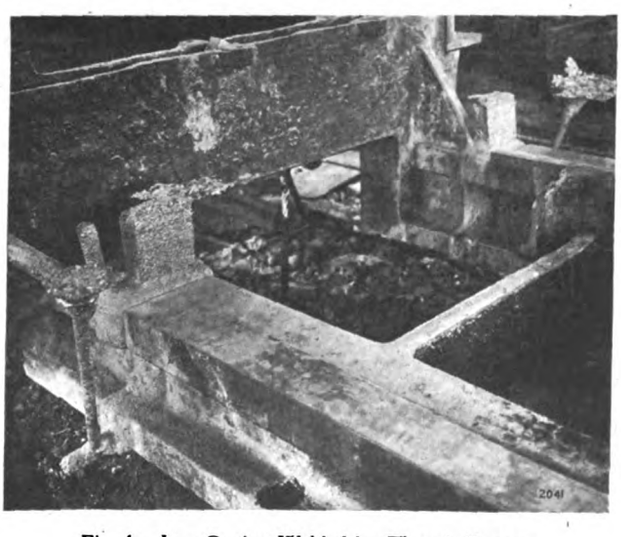

Fig. 1.—Iron Casting Welded by Thermit Process

as it flows between the fracture melts by reason of its excessive temperature (5,000 degrees F.) a considerable amount of the metal of the parts and cooling solidifies with the parts. In actual practice the reaction is tempered by the addition of mild-steel punchings, and the quality of the steel is improved by the further addition of manganese, nickel, etc. For the welding of cast iron, "cast-iron thermit" is recommended instead of "railroad thermit," which is usually used for the repair of steel and wrought-iron sections.

This form of welding is particularly suitable for the welding of large sections, and if the fracture is in such a section its use might be advisable, making it possible to complete repairs with the cylinder in place. Generally speaking its field of application for this class of work is limited, but on heavy sections it has the advantage over any other form of welding in the fact that the weld is all made at one time, and there is therefore, but one shrinkage, which, if properly allowed for, avoids the possibility of locked-up stresses and shrinkage strains. Fig. 1 shows the general method of making such a weld.

Gas Welding

At the present stage of development of cast-iron welding, there is no doubt that, generally speaking, from the standpoint of strength, gas welding should be used wher-

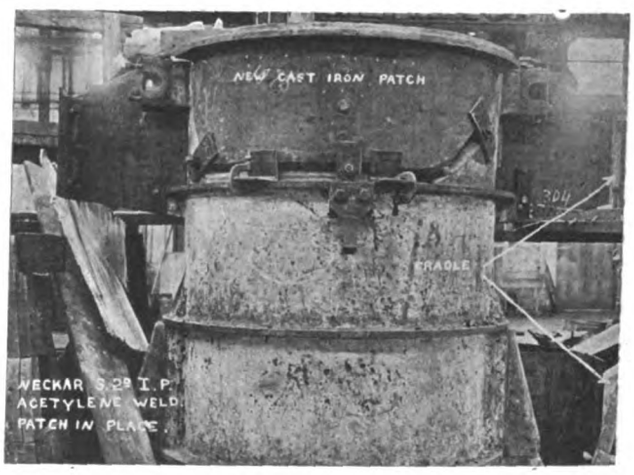

Fig. 2.—Engine Cylinder of S. S. *Neckar* with Patch in Place for Oxy-Acetylene Weld

ever possible, but its use on marine engine cylinders is limited by the following:

(a) The necessity for preheating, frequently requiring the cylinder to be dismantled and taken to the repair shop.
(b) The likelihood of setting up strains due to preheating in parts of the cylinder remote from the area under repair.
(c) The discomfort to the operator when welding on a large preheated job.
(d) The relative difficulty of welding with the same ease and reliability in vertical and overhead positions, as in flat or horizontal positions.

This method of welding cast iron has been in successful use for several years in large railroad shops. The section to be welded is brought up gradually to a "black" heat, either by the gas torch or a charcoal fire, depending on the nature and complexity of the job. After this is done a rod of cast-iron welding material is gradually melted by the torch into the V'd-out section, and then melted into the fused puddle under the torch tip, thereby

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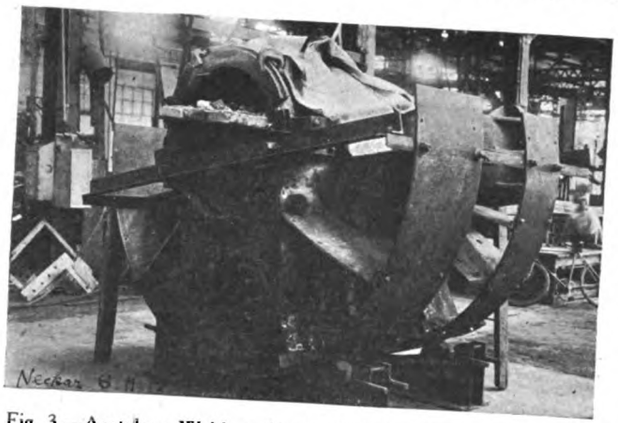


Fig. 3.—Acetylene Weld on *Neckar* Cylinder Partly Made. Note Mounting to Keep Puddled Metal Horizontal

obtaining perfect cohesion and eventually closing the opening.

The best results are obtained when the weld is made horizontally, the metal being deposited from above. Good work has been done both vertically, and even overhead, by skillfully handling the torch, and at the same time aided by the use of carbon blocks and paste.

Fig. 2 shows the intermediate cylinder of the German ship *Neckar*, with the cast-iron patch in place. All the welding on this job was done in a "flat" position. To facilitate this a cradle was attached to the cylinder, which was rotated as the welding progressed (see Fig. 3).

The preheating of the section to be welded was done by a charcoal fire, the bed for which is clearly shown in Fig. 3. Fig. 4 shows the completed job, which on test showed no leaks whatever. Many examples of this class of work are being done throughout the country. One job recently brought to our notice had 27 linear feet of welding.

Electric Arc Welding

This form of welding has the advantage in that only the immediate section being welded is heated, and only at the time the metal is being deposited in the weld. Due to this the general strains in the casting are reduced to a minimum, and this method of welding should therefore be employed when the casting is a complicated one. It further has the advantage of permitting the work to be done on board ship with the cylinder in place, thereby saving time.

The welding of cast iron, however, by means of the electric arc (both carbon and metal arcs) does not give, as a rule, the cohesion and homogeneity attainable by means of thermit or the gas flame.

If the carbon arc is employed, the method of welding is similar to gas welding, the metal filler rod being fed into the arc instead of into the gas flame. Having almost the same limitations as the gas torch, the carbon arc is, to date, seldom used in marine cylinder work.

For metal-arc welding, the electrode usually used is a mild steel rod varying in diameter from ⅛ to¼ inch, depending upon the size of the work. Phosphor bronze and cast-iron electrodes have also been used to advantage. Phosphor bronze is objectionable because of its low melting point and high coefficient of expansion. It is difficult to procure cast-iron electrodes of uniform homogeneous structure, which at the present time limits its use, but there is no doubt that, as this difficulty is overcome by improved manufacturing processes, and with the development of suitable fluxes, coatings, and coverings, its use will be greatly extended

Cast iron contains a high percentage of free carbon, and has a lower melting point than mild steel. When added,

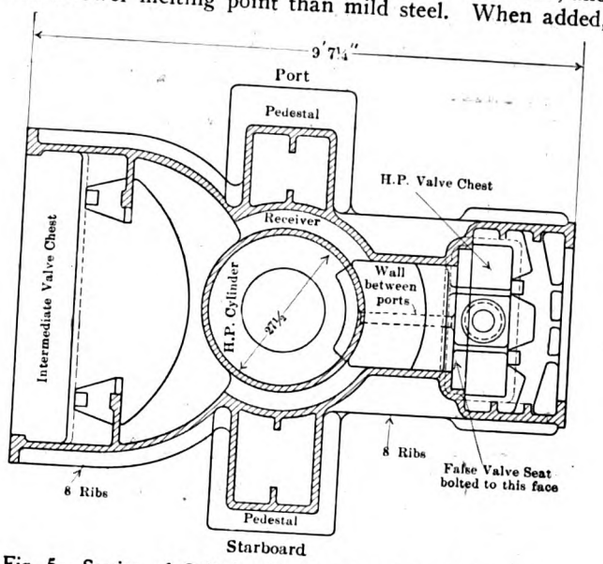
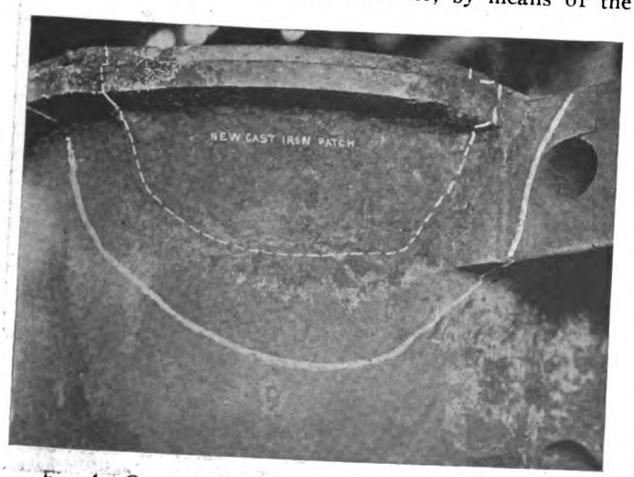


Fig. 5.—Section of Cylinder Showing Complicated Construction



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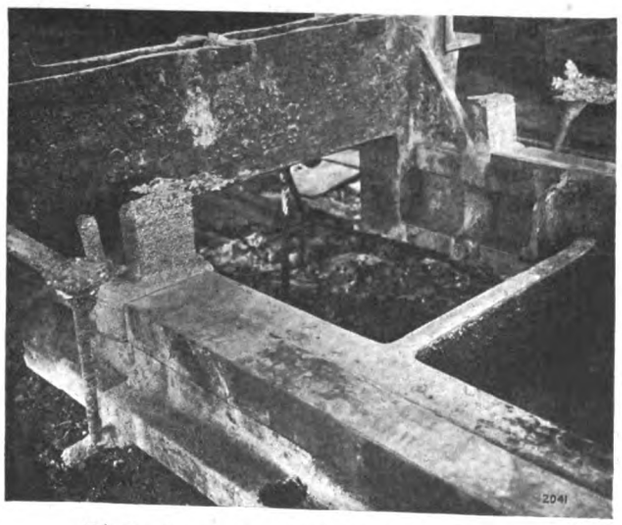

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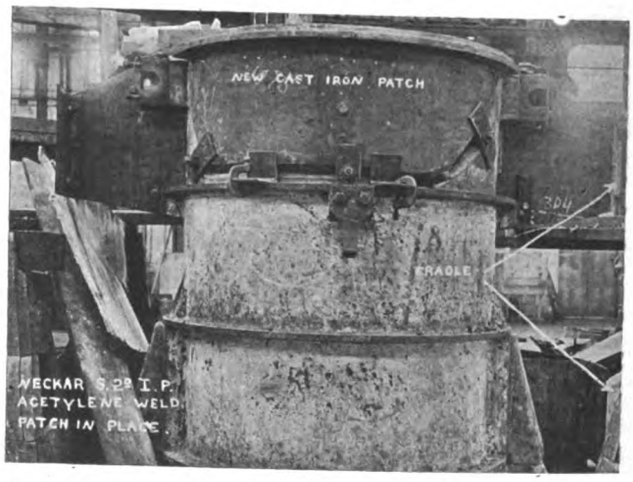

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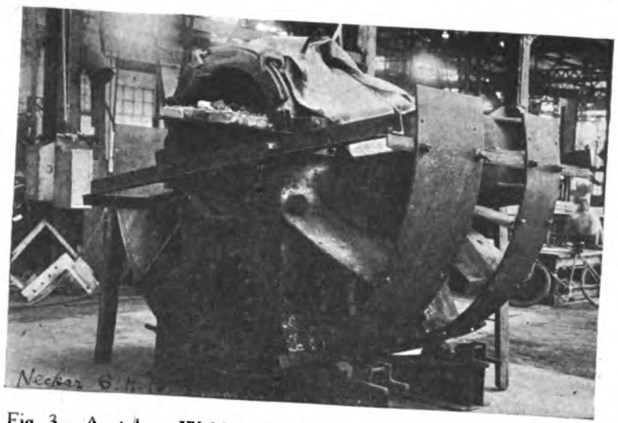

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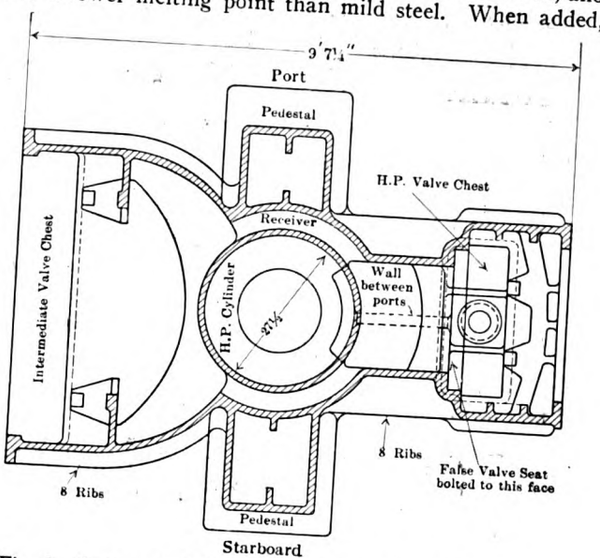

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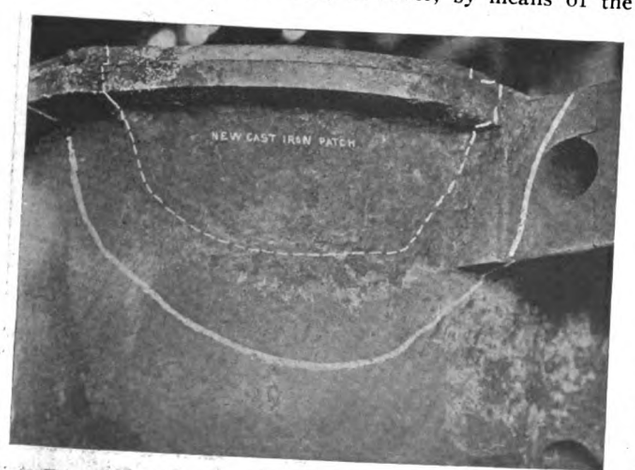

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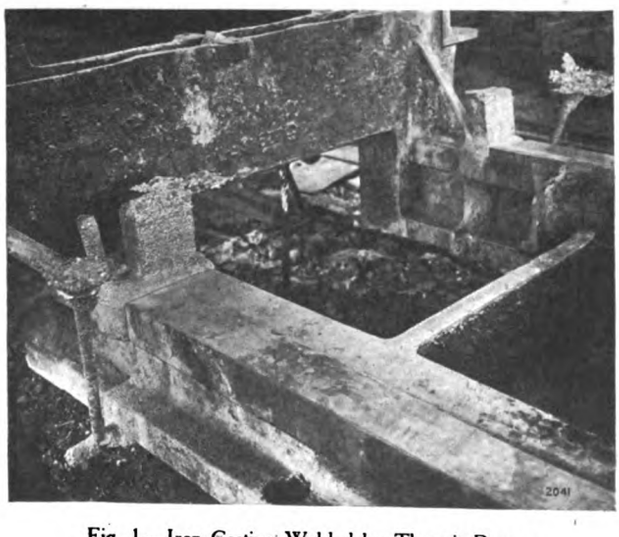

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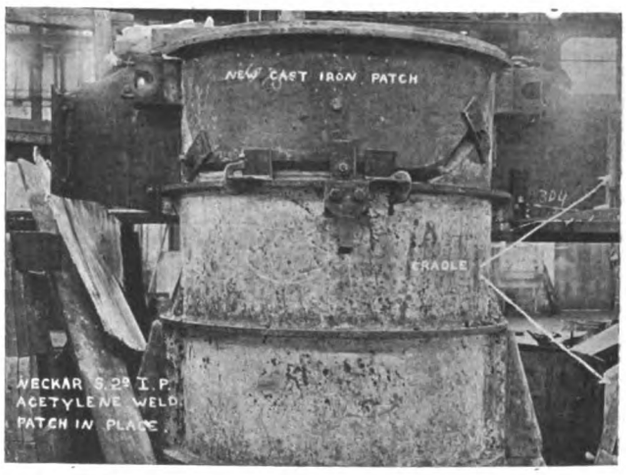

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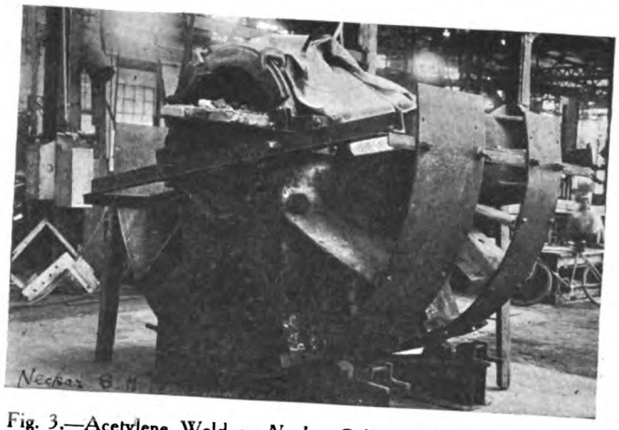

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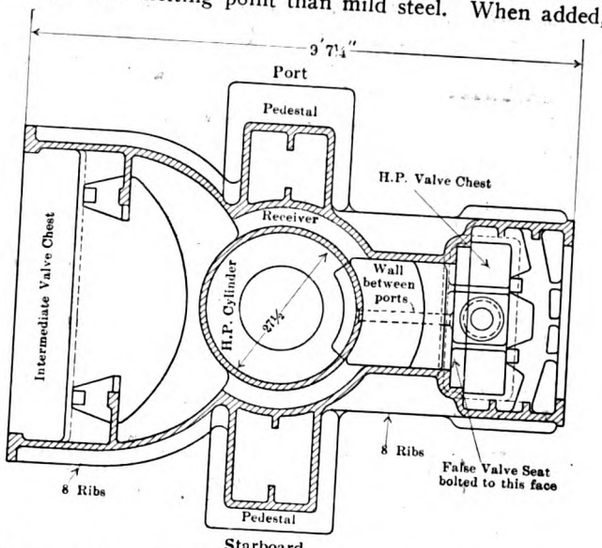

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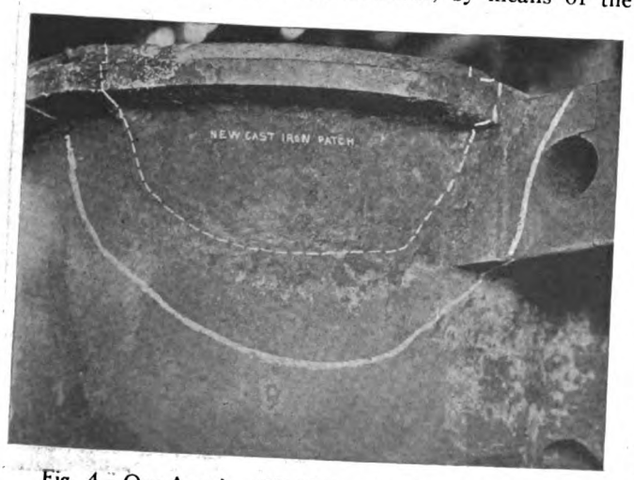

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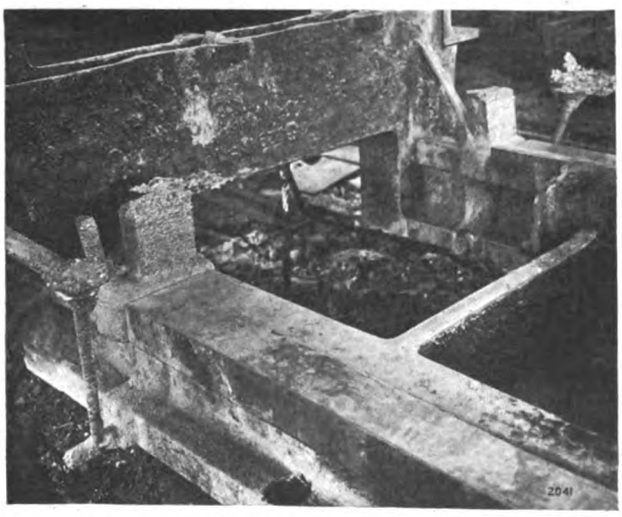

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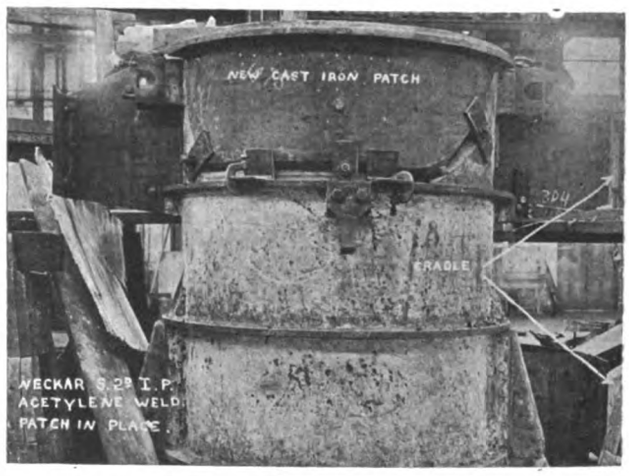

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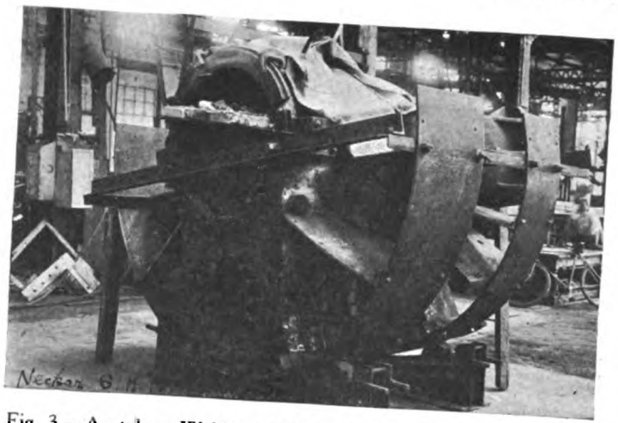

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For metal-arc welding, the electrode usually used is a mild steel rod varying in diameter from ⅛ to¼ inch, depending upon the size of the work. Phosphor bronze and cast-iron electrodes have also been used to advantage. Phosphor bronze is objectionable because of its low melting point and high coefficient of expansion. It is difficult to procure cast-iron electrodes of uniform homogeneous structure, which at the present time limits its use, but there is no doubt that, as this difficulty is overcome by improved manufacturing processes, and with the development of suitable fluxes, coatings, and coverings, its use will be greatly extended

Cast iron contains a high percentage of free carbon, and has a lower melting point than mild steel. When added,

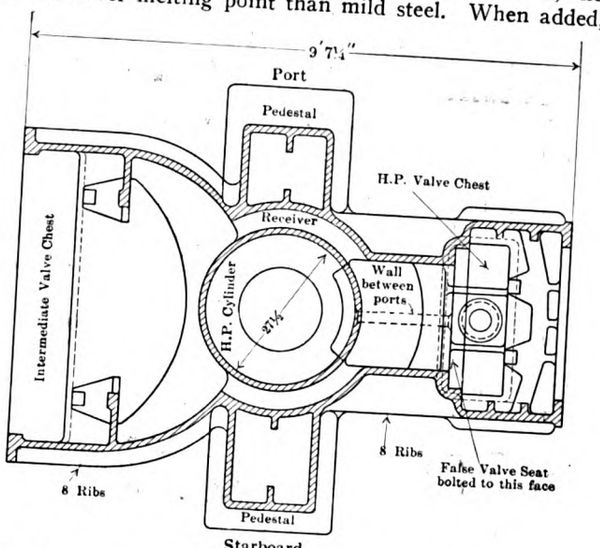

Fig. 5.—Section of Cylinder Showing Complicated Construction

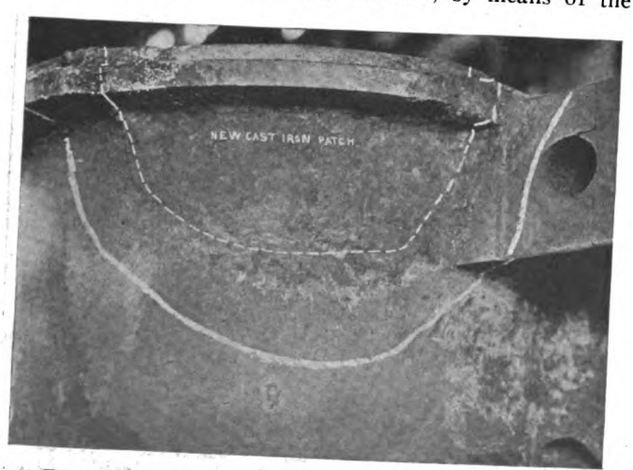

Fig. 4.—Oxy-Acetylene Weld Completed on Cylinder of S. S. *Neckar*

the free carbon of the cast iron unites with the lower carbon steel of the electrode, causing a layer of chilled high-carbon steel to be deposited in the weld at the junction of the electrode material with the cast iron. This is only about ⅛ inch thick, but, being brittle, the weld is easily broken. To overcome this difficulty, cast iron when welded by the electric arc is usually studded, ⅜-inch mild steel studs, ¾ inch long being the most commonly used.

This deposit of high-carbon steel also causes trouble, when it is necessary to machine the surface after welding as the tool will ride over hard spots and dig into the soft metal on both sides of it. This disadvantage may yet be overcome by the development of a more suitable electrode.

The Fractured Cylinder

Fig. 5 is a sectional plan of the high-pressure cylinder of the Dutch ship *Rondo*, and together with the other sketches of this cylinder gives some idea of its complicated nature.

It embraced, in the center, the high-pressure cylinder; on the right, the high-pressure valve chest; and on the left, the intermediate-valve chest (see Fig. 5). The receiver connecting these two-valve chests forms an integral part of the casting and passes through the pedestal shown

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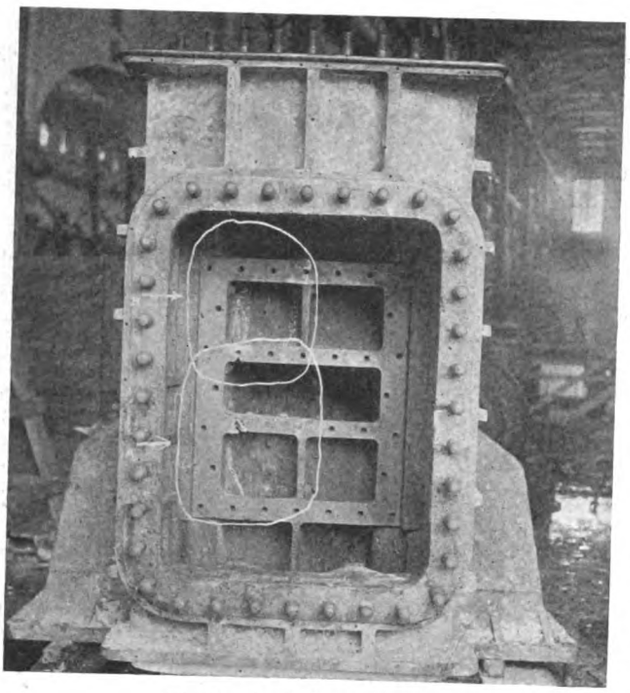

Fig. 6.—Cracked Valve Chest

in Figs. 6, 9 and 10. The valve ports *A* and *B* (Fig. 6) had been previously repaired by a welding company in March, 1918. Repairs were made by arc welding and by riveting a 10-pound plate and a 3½-inch by ⅞-inch steel bar to the port walls. After these repairs, two trips were made to Europe, but the leakage was too great to continue the high-pressure cylinder in service.

The *Rondo*, of 10,810 gross tons, built in Holland in 1914, was chartered by the United States Government. The diameter of high-pressure cylinder is 27½ inches, with a 53-inch stroke. The indicated horsepower of the engine is 5,100.

The mechanical and thermal stresses to which a weld in the port walls would be subjected to are:

First, a rapid change of pressure from 215 pounds in the high-pressure cylinder to between 40 and 60 pounds in the intermediate cylinder.

Second, a sudden change of temperature from superheated steam at 510 degrees to saturated steam at 307 degrees.

The Breaks

Figs. 6, 7 and 8 show the badly cracked steam-port walls on the starboard side, these having been welded as previously noted. Fig. 7 shows break 6-*A* enlarged, and Fig. 8 shows break 6-*B* enlarged.

These cracks were probably caused by a flood of water when the engine was being "warmed" up.

A circumferential crack about 20 inches long was found immediately over both the starboard and port pedestals (Figs. 9-*A* and 10-*A*). This was probably caused by a bending moment in the cylinder due to the overhang of the pedestals.

There was also an axial crack in the cylinder wall on the starboard side about 19 inches long, which extended through the top horizontal flange (Figs. 9-*B*, 14-*D* and 15-*D*). This was very likely due to a tendency to articulate on account of the extreme fore and aft length of the cylinder, or it occurred in the removal of the "frozen" liner, which eventually had to be chipped out its entire length for removal. There was one other axial crack on the starboard side of the pedestal (Fig. 9-*C*), probably due to surface shrinkage. This was not serious, as it was not welded and did not leak when the cylinder was tested.

Preparation for Welding

The port walls to be repaired were entirely cut out (Fig. 11). An oval access hole 12 inches by 18 inches (Figs. 11-*D*, 12-*D* and 15) was cut in the cylinder wall, in order to

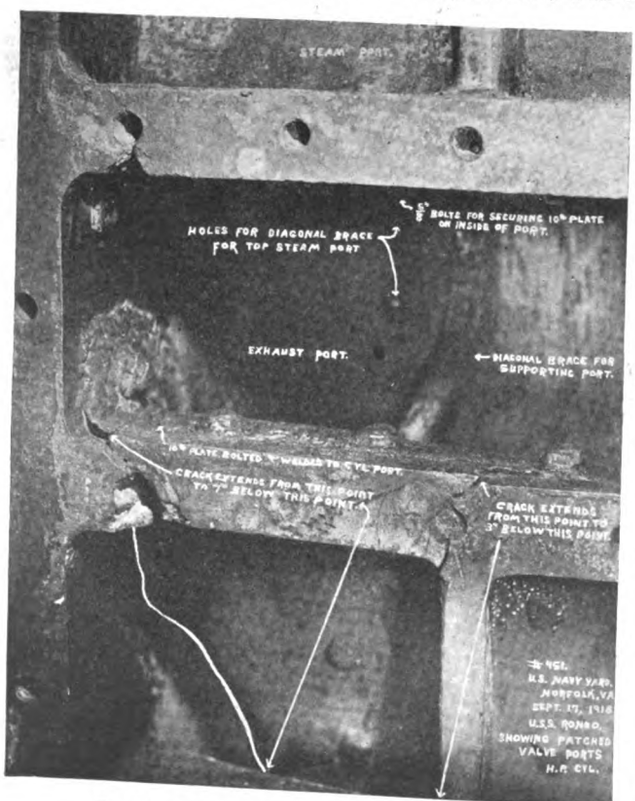
STEAM PORT.
HOLES FOR DIAGONAL BRACE FOR TOP STEAM PORT
BOLTS FOR SECURING 10# PLATE ON INSIDE OF PORT.
EXHAUST PORT.
DIAGONAL BRACE FOR SUPPORTING PORT.
10# PLATE BOLTED & WELDED TO CYL. PORT
CRACK EXTENDS FROM THIS POINT TO 7" BELOW THIS POINT.
CRACK EXTENDS FROM THIS POINT TO 3" BELOW THIS POINT.
U.S. NAVY YARD, NORFOLK, VA. SEPT. 17, 1918. U.S.S. RONDO. SHOWING PATCHED VALVE PORTS. H.P. CYL.

Fig. 7.—Enlarged View of Break "A," Fig. 6

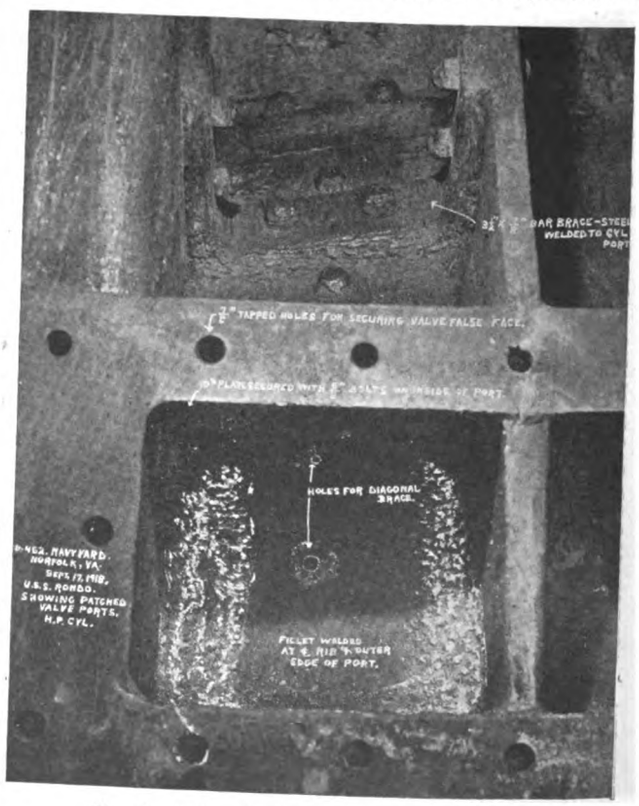
TAPPED HOLES FOR SECURING VALVE FALSE FACE.
HOLES FOR DIAGONAL BRACE.
FILLET WELDS AT ℄ RIB & OUTER EDGE OF PORT.
U.S. NAVY YARD. NORFOLK, VA. SEPT. 17, 1918. U.S.S. RONDO. SHOWING PATCHED VALVE PORTS. H.P. CYL.

Fig. 8.—Enlarged View of Break "B," Fig. 6

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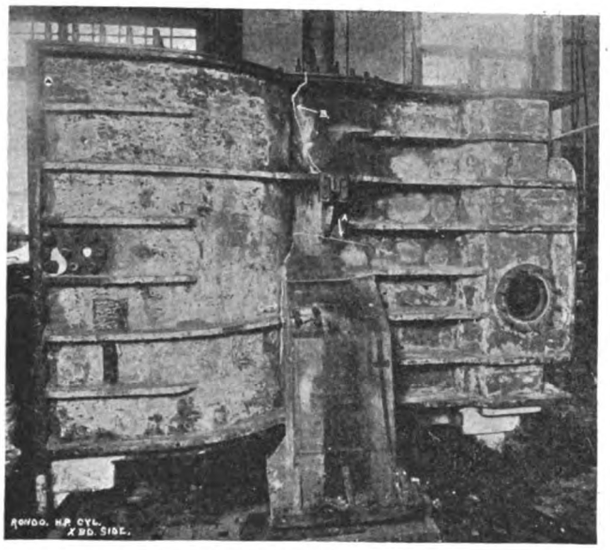

Fig. 9.—Cracks, Starboard Side

Fig. 10.—Cracks, Port Side

weld the new port walls in place as shown in Figs. 13-*A* and 17-*A*.

The exact length of the cracks in the cylinder walls was determined by sand blasting. A hole was drilled at the ends of each crack before chipping out to a 90-degree bevel. All bevels, valve-port walls and the hole in the cylinder wall, were studded and a ¼-inch calking groove 3/16 inch deep cut longitudinally between the studs for steam tightness (Figs. 12 and 18).

Patterns, Fig. 16, from which steel castings were made, were fitted for the new-valve port walls and for the patch in the cylinder wall.

Technique Followed in Welding

Direct current, 70 volts (open circuit), 120 amperes and ⅛-inch bare electrodes were used.

The calking groove was carefully welded, the studs surrounded with metal and the intermediate surfaces gradually filled up until the electrode material deposited was flush with the top of the studs (Figs. 13 and 18). Both surfaces of the bevel were at the same time built up (Fig. 18).

Patches were not put in place until a ½-inch pad of electrode material was built up on the cast-iron surface to which they were to be attached (Figs. 13 and 19). A handle was welded to each patch to facilitate its being put in place (Fig. 14-*B*).

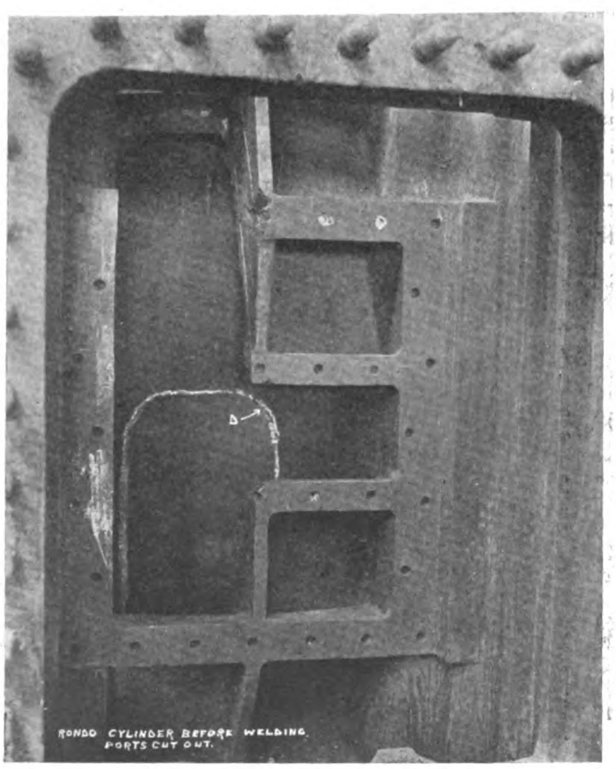

Fig. 11.—Ports Cut Out Before Welding

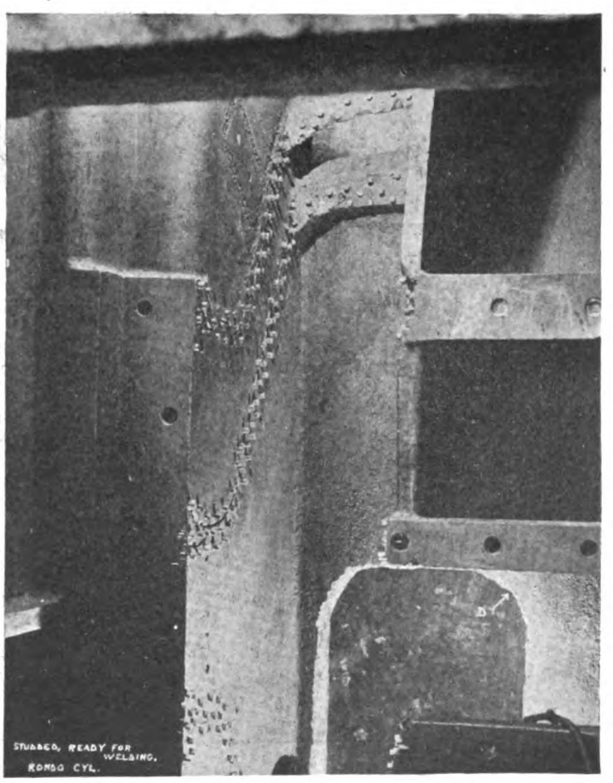

Fig. 12.—Cylinder Studded, Ready for Welding

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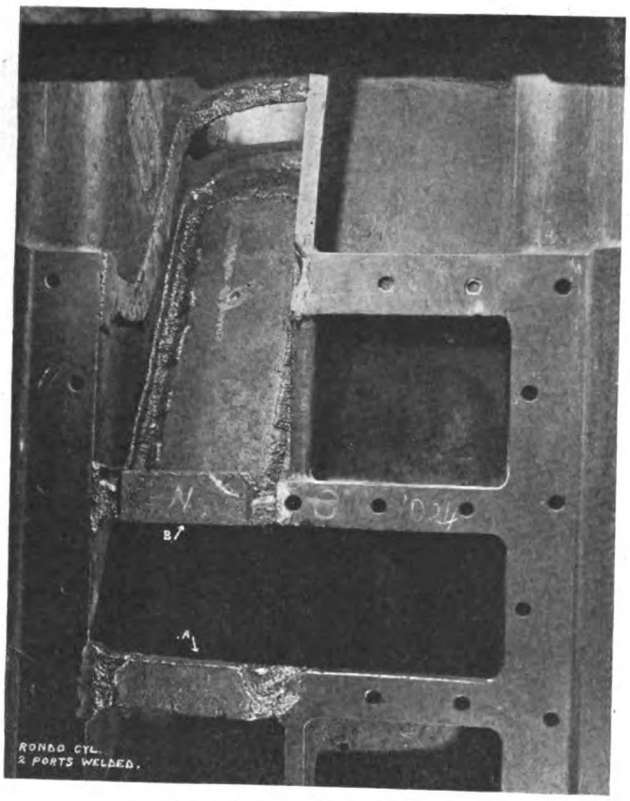

Fig. 13.—Two Ports Welded

As a patch was put in, it was tack welded, and great care was used to avoid overheating of a local section.

As soon as the temperature of the metal two inches from the weld rose above what the bare hand could stand, welding was moved to another spot. Even with this precaution an occasional section of deposited metal had to be chipped out. The oxide deposited on layers was removed by means of a hand brush before additional layers were put on.

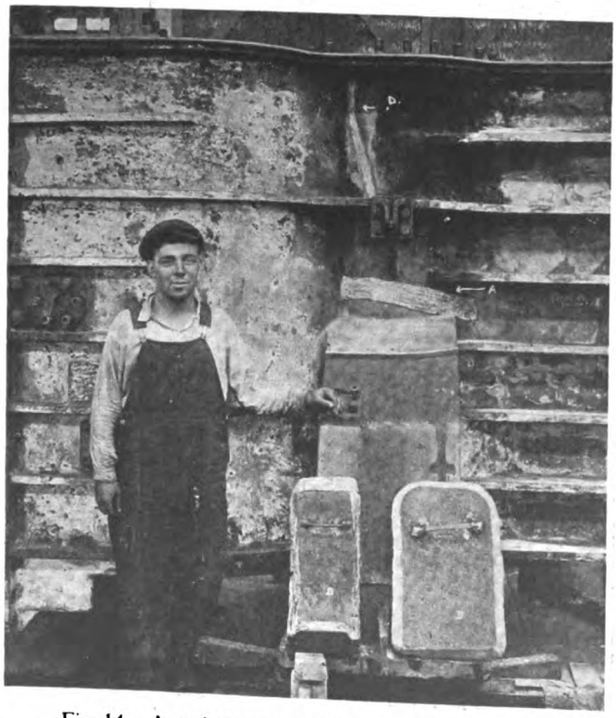

Fig. 14.—A and D, Cracks Welded. BB, Two Patches

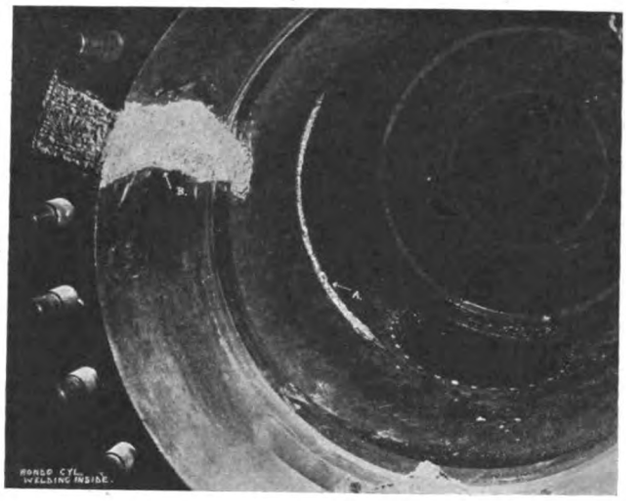

Fig. 15.—Position of Welds Inside Cylinder

Fig. 16.—Patterns for Patches

Fig. 17 shows a cross section through the valve ports and chest, and the side of the steam-port wall on which a bevel was made for welding. Wall *A* was the first one put in place and welded by the operator working from the inside of the cylinder, through a hole cut for this purpose. Wall *B* was the next one, and finally wall *C*. Fig. 13 shows *A* completely welded, *B* partly welded, and *C* not yet in place. After this was completed, patch *D* in the cylinder wall was welded.

TESTS

When the ports were faced off for the false valve seat, the section of hard-welding material referred to earlier in the article caused the cutter to cock out and cut into the softer cast iron. This was particularly bad in two cases and was remedied by beating down the ridge with a hammer. When hammering was not effective a small "V" section was chipped out, a ⅜-inch hole drilled and a mild steel stud inserted, which was machined off flush (Fig. 20). A little magnesite was put in the chipped out "V" when the false valve seat was put in place, and together with the stud formed a steam-tight joint. In subsequent work of this kind, the "V" left after the hard spots are chipped out has been filled up using a bronze electrode. As the bronze does not harden in cooling, the surface may be readily machined.

The cylinder was given a series of tests in the shop to determine its steam tightness. To do this, it was set vertically, the heads put on top and bottom, the ports blanked off, a steam-line run to the top head and a water line to the bottom one.

Water was now pumped in and the temperature gradually raised to 150 degrees by forcing steam through it for a period of five hours. At the end of this time, the hydraulic pump was started and the pressure gradually

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raised to 50 pounds in five minutes, which, however, could not be increased beyond this point, as the seepage was too great in nearly all the welds. The pressure was now reduced, some sal ammoniac dissolved in the water and allowed to stand for a few hours.

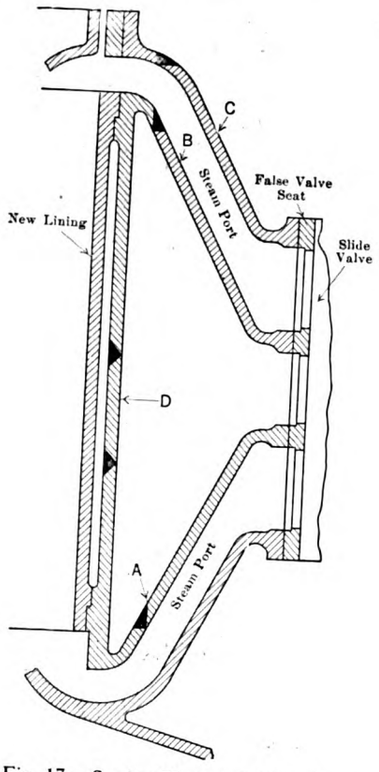

Fig. 17.—Section Through Valve Chest

It might be mentioned here that at least one large automobile manufacturing company uses sal ammoniac to stop porosity in the cylinders of all their cars, both passenger and motor truck. The cylinder is filled with a dilute solution of sal ammoniac in water and baked in an oven for several hours.

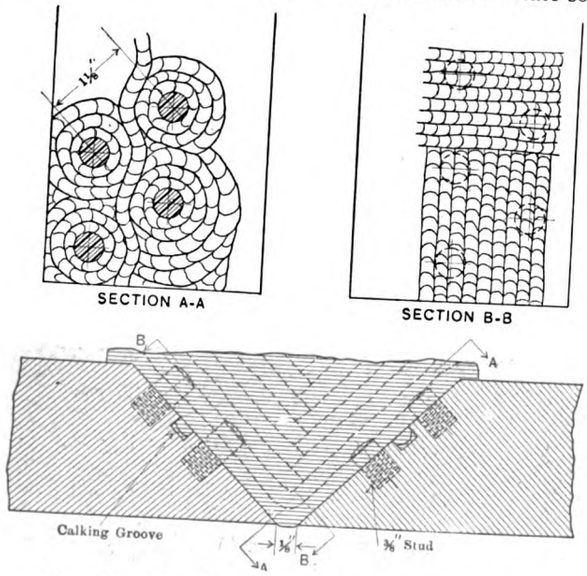

Fig. 18.—Preparations for and Methods of Welding

After the sal ammoniac treatment, a steam test was applied, the pressure being raised to 225 pounds, at which point it was cut off. Only a few small leaks were observed.

The last test applied to the cylinder was after assembly on board the ship, when it was observed during a dock trial. The engine was warmed up for 10 hours before being started, and then run with 110 pounds boiler pressure. The welds in the walls showed a little porosity in two spots, one on the starboard and the other on the port side of cylinders; but this soon disappeared.

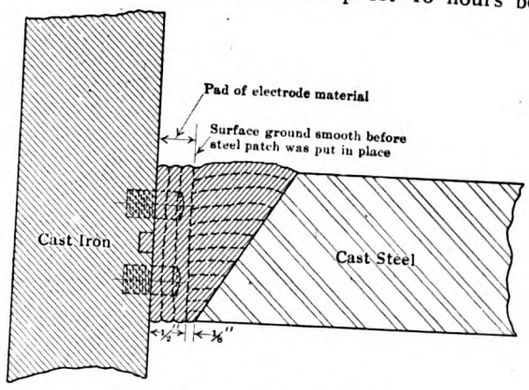

Fig. 19.—Method of Welding

An indicator card of the high-pressure cylinder taken at this time showed that the valve ports were essentially steam tight (Fig. 21).

An indicator card of the high-prssure cylinder (Fig. 22) was taken on the last trip to Europe, previous to docking for repairs. When compared with cards taken at the same time for the intermediate- and low-pressure cylinders, it showed only about one-half the indicated horsepower of either one. Approximately the same horsepower was expected, if the valve ports were in good condition.

No good comparison can be drawn from these cards, as the card shown in Fig. 21 was taken alongside the dock at 110 pounds pressure, and the card shown in Fig. 22 was taken at 210 pounds pressure at sea. Both cards were taken with a 100-pound spring. A card taken under similar conditions to Fig. 21 is not available.

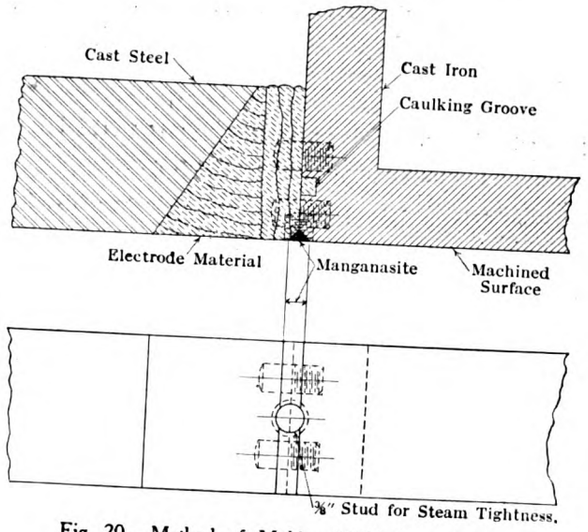

Fig. 20.—Method of Making Weld Steam-Tight

The ship left the Norfolk Navy Yard on December 21, 1918, and on February 24, 1919, the engineer wrote as follows:

"Horsepower-valve chamber was examined after a run

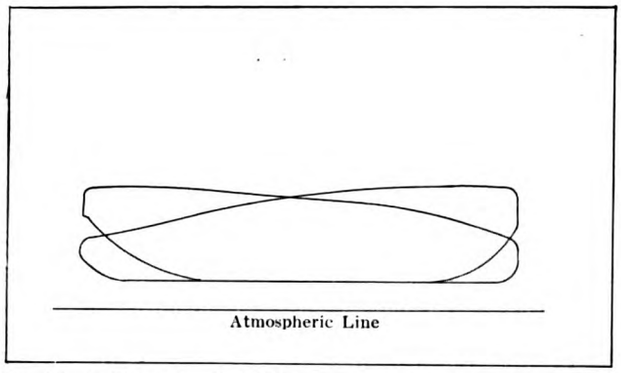

Fig. 21.—Indicator Card of High Pressure Cylinder Taken at Dock Trial with Ports Repaired

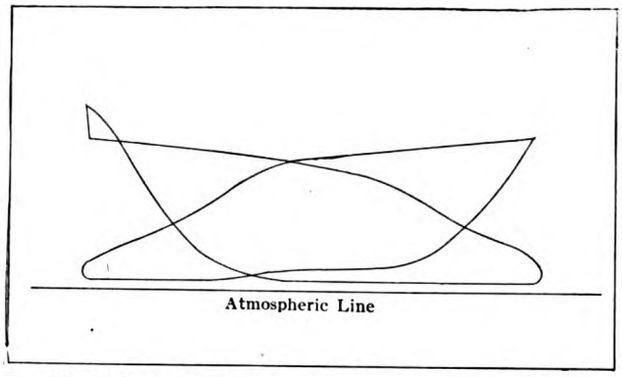

Fig. 22.—Indicator Card of High Pressure Cylinder Taken at Sea with Ports Broken

of 5,850 miles. The welding and patches put on at the Norfolk Navy Yard show no signs of working, and are in good condition at the present time."

COMPARATIVE TIME AND COST

The labor and material of welding cost approximately $1,870 (£384), the items being:

(1) Welding and preparation for welding....	$1,760.00
(2) Patterns for patches.....	60.00
(3) Casting of patches.....	50.00
	$1,870.00

Shipbuilding Gives Great Impetus to Oxy-Acetylene Industry

Process Plays Big Part in Present-Day Yard

BY RUFUS COPELAND

UNPRECEDENTED building of ships in United States shipyards has resulted in a remarkable stimulus to many related industries. Referring casually to the effect of America's shipbuilding program on the oxy-acetylene industry, an official of the Oxweld Acetylene Company, probably the largest manufacturers of oxy-acetylene blowpipes and generators in the world, said recently, "Our business has grown enormously the past few years, primarily as a result of the adoption of oxy-acetylene cutting and welding in practically all branches of manufacture, where the processes enter more and more into production as elements of economy and speed, often superseding methods that had long been considered the ultimate in manufacturing efficiency. This has been observed notably in the shipyards of the country, and has

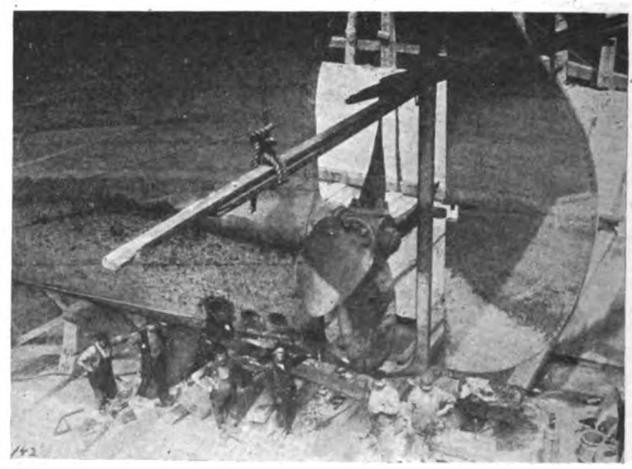

Fig. 1.—Cracked Stern Post Repaired in Seven Hours by Two Operators

contributed in an appreciable degree to the amazing increase in American shipbuilding activities."

Another authority, speaking of the Linde Air Products Company and the gas division of the Prest-O-Lite Company, each of which is national in scope and service, said, "While the great increase in the use of oxygen and acetylene gases is a result of the wider application of oxy-acetylene processes in general industry, growth in shipbuilding has been an important factor in the recent development of these businesses."

Fig. 2.—Forged Steel Rudder Frame

The accompanying pictures show welding operations that a few years ago would have been considered remarkable. To-day they are but minor operations in an application of oxy-acetylene to present-day shipbuilding, and as such are typical of common, everyday work in the average shipyard. Fig. 1 shows a stern post that was cracked by scraping on a shoal. The post is seven inches thick and weighs 28 tons, and the crack was 11 inches

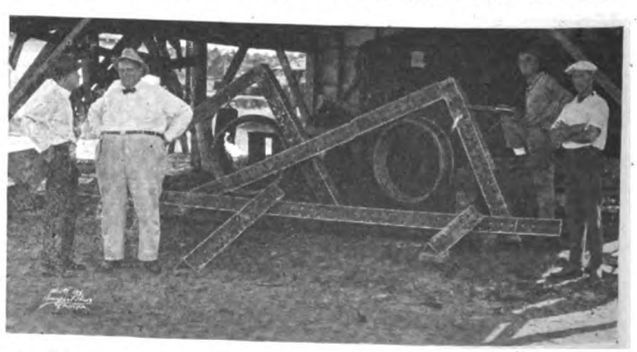

Fig. 3.—Anglesmith Work Done by Oxy-Acetylene Welding at Oscar Daniels Shipyard, Tampa, Fla.

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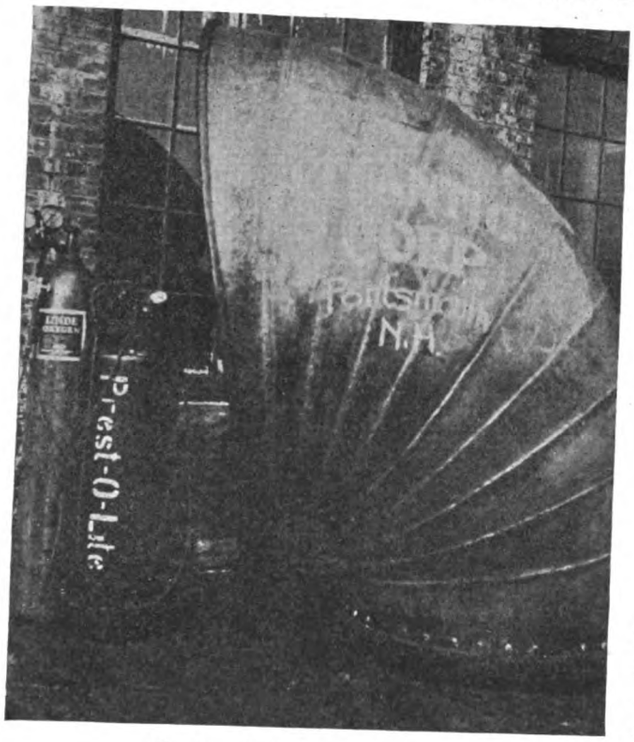

Fig. 4.—Welded Ventilator Cowl

long, extending vertically. It was repaired in seven hours by two operators. Fig. 2 represents a three and a half-ton steel rudder frame, valued at $1,200 (£257). It was cracked and successfully welded in two places. Fig. 3 shows anglesmith work done by welding. Fig. 4 is a welded ventilator cowl. Fig. 5 is an example of all-welded oil tanks.

The only difference between these operations with oxy-acetylene and those of a few years ago is the fact that they are welding jobs. The use of oxy-actylene for cutting is somewhat older in accepted shipyard practice. Fig. 6 shows a minor operation of this type.

Oxy-acetylene in its application to shipbuilding, therefore, is not new. Prior to the war it was used extensively, though not so extensively as to-day, in the cutting division of the industry.

Among the uses to which it is devoted, and which have been authorized by the American Bureau of Shipping, may be enumerated the following—a considerable and constantly expanding list:

Welding

Ventilators and all light-gage air ducts leading from ventilators to ship compartments; smokestacks, boiler

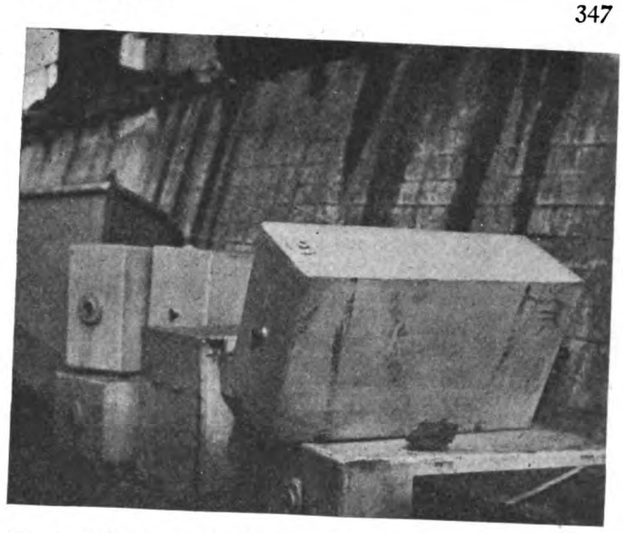

Fig. 5.—All Welded Oil Tanks, Toledo Shipbuilding Company, Toledo, Ohio

uptakes and boiler casings made of light-sheet steel; deck-rails and deck-rail supports (several hundred supports and hundreds of feet of pipe railing to each ship); ladders (welded ladders much stronger than bolted ones, affording greater strength to tread and security from accident); stairways, floor grating, bulwarks, skylights, frames and casings, hinges, tanks, hatch covers, mast seams, coal chutes, castings, manhole rings, channel and Tee bars, "I" beams, flange-steel tubing, davits, stanchions, bushings.

Tanks of every nature are welded, notably lubricating oil storage tanks, fresh-water tanks, reserve oil tanks, food-storage boxes, etc. Welding is also used in attaching ventilator and smokestack deck collars, and for butts of watertight and oiltight boundary bars on bulkhedas or floors in double bottoms. Engine and boiler room flooring is laid on welded supports. Cleats and other fittings are welded to angles or plates.

Cutting

Ventilators (cutting plates to shape for welding of ventilators, tanks, etc.); angles for subsequent welding into staples, etc.; holes in plates, frames, manholes, chains, mast openings, stairway openings, channel openings, angle irons, shafting, channel irons, pipes, stem and stern posts, headlights, scrap.

Heating

Plates, channel irons, rivets; also for bending angle and channel irons and repair work in connection with damaged vessels, damaged plates and braces, machinery, and for cutting rivet heads and filling of misplaced punch holes.

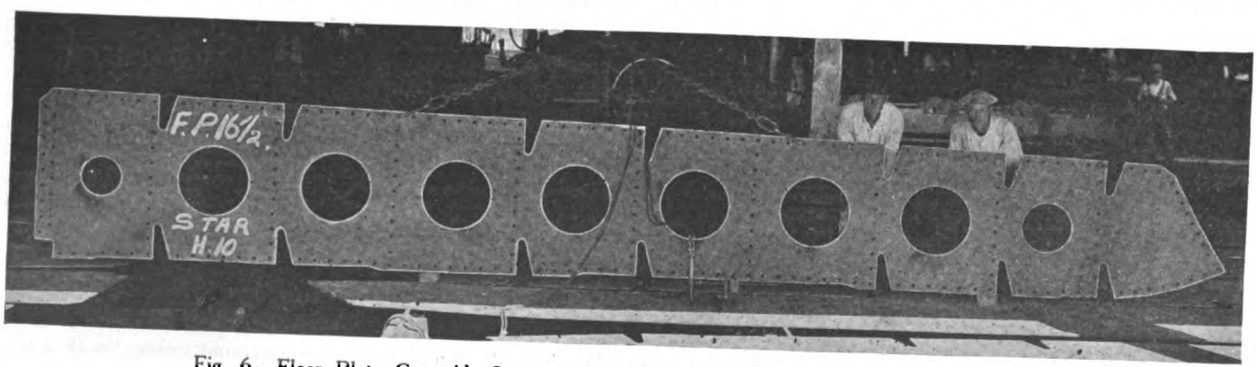

Fig. 6.—Floor Plate Cut with Oxy-Acetylene Torch, Oscar Daniels Shipyard, Tampa, Fla.

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Permissible Ship Welding

BY WILLIAM T. BONNER*

PREVIOUS to November, 1917, electric welding had not been officially recognized by either of the principal classification societies and, if we may except a few special permits for specific undertakings of minor importance, no really serious consideration was given to welding as a means of constructing ships.

During the greater part of 1916, the writer was engaged in research work in connection with the development of various forms of jointures for ships' plating, including not only the conventional riveted seams prescribed by Lloyds and the American Bureau of Shipping, but every form of lap and butt weld within the limitations of electric arc, resistance or "spot" welding, and the fused jointures made with gas flame.

While these investigations were made, primarily, in the interest of certain operators who wished to determine which of the many types of jointures were most efficient and durable for their ships, the door was kept constantly open for the admission of the classification societies, that they might also note the results and be prepared to supplement their rules with permits to use such forms of welding as should prove dependable.

One important section of the above research embodied a series of tests carried out under the direction of the writer, at the Bureau of Standards in Washington. These were not of the usual laboratory sort. Each sample tested had been built in a shipyard by regular workmen, in strict accordance with Lloyds rules and with standard specification materials. The results, therefore, were regarded by Lloyds as dependable to the extent of determining values for welded jointures within the limitation of careful workmanship. Very early, however, it was found that the personal equation had much to do with the dependability of a weld, and while certain safeguards have since been devised for avoiding the ordinary dangers it must be admitted the latest lists of permissible welding are not as extended as they might be were our welders universally capable and honest.

Under date of November 9, 1917, the writer, then engineer of welded ship construction for the Merchant and Chester Shipbuilding Corporations, formally submitted for approval by Lloyds the following list of parts which he had prepared as typical of what should be regularly fabricated by welding. In a covering letter of November 16, 1917, the writer, referring to this list, stated:

"The basic principle upon which we have built above list insures the maintenance of all weather decks, plating and casings free from piercing for rivets, etc., and provides increased strength by the several increments of weld material. * * * It is with greatest confidence, therefore, that we submit aforesaid list as *suggestions* and ask your approval of our recommendation that they be fabricated by electric welding as far as the design of ship and conditions of construction permit."

In response to the above letter, Lloyds addressed the writer, under date of November 19, 1917, as follows:

"As requested during your recent visit, we have carefully considered the list of ships' parts which you would suggest electrically welding in the ships now building by the Chester Shipbuilding Corporation, and have pleasure in returning to you a copy of this list, having indicated thereon by means of an asterisk the items which we are prepared to accept as electrically welded, providing the welding be done to the complete satisfaction of our surveyor."

The following is a verbatim copy of the original list as submitted by the writer to Lloyds on November 9, 1917, even to the inclusion of the typographical error in the sixteenth* item, which was inadvertently written as "Door Frames to Casing, Hinges, Catches Hold Each-Hooks, etc.," instead of "Door Frames to Casing, Hinges, Catches, Hold-back Hooks, etc."

Incidentally it has afforded the writer considerable amusement and no little satisfaction to note that for more than two years the various publishers of this "standard list of weldable ships' parts" have, one and all, sent it out "as is," apparently with no thought as to its proper meaning.

SHIPS' PARTS SUGGESTED FOR ELECTRIC WELDING

All coamings for hatches, bulkhead doors, etc.
Corners of all O. T. hatch coamings.
Hatch cleats to coamings.
*Deck rail stanchions to plating.
*Clips for detachable rail stanchions.
*Continuous railing rods (joints).
Attaching doubling plates.
* " deck collars (L-rings) around ventilators.
" " " " " blow-off pipes.
* " " " " smoke stack.
* " cape rings " " pipes, etc.
* " galley fixtures to plating.
* " bath and other fixtures in officers' quarters.
" cowl supporting rings to ventilators.
" L-bar clips to deck for bulwark stanchions.
" All fixed manhole covers to tank top and deck plating.
Fabricating base and cap L-rings for 'tween deck pillars.
Attaching pillar bases and caps to plating.
*Bulwark rail top splicing and end fitting.
Fidley top plating joints.
Engine and boiler room casing above trunk deck.
Coaling hatch frames.
Attaching cleats and other fittings to ditto.
Skylights over engine room, galley, etc. frames and covers.
* (a) Engine room stairs and gratings.
* (b) Boiler " " " "
*Attaching (a) and (b) to plating.
*Grab rods on casing.
Engine and pump room chairs and brackets.
Mast brackets to deck and mast—with supplementary rivets, if required by inspector.
Winch and windlass brackets and supports.
Attaching hawse pipe L-ring to deck.
Smoke stack casing foundations and brackets.
*All stairs and ladders including rail attachments.
*Door frames to casing, hinges, catches, hold each-hooks, etc.
Davit sockets to deck.
Bracket supports for davits.
Chain locker casing, foundations and fittings (eye pads to have supplementary rivets, if required by inspector).
*Clips for attaching interior wood finish to casing.
Deck house casing—companion ways, etc.
Filling up drop holes.
Bilge bracket gusset braces.
Flanges on steam and hydraulic piping.
Bollards, fairleads and mooring pipes.
Deck cleats and chocks.
*Entire screen bulkhead.
*Also coal chutes.

At various times during the two years following the issuance of the above list the classification societies accepted for approval applications from shipbuilders to weld additional parts in order to meet unusual war conditions, and because of further developments in the welding art. In the meantime Lloyd's British offices were giving constant attention to the development of welding and, as a result of their findings, the following circular (No. 1328) was issued by the committee, under date of October 6, 1919, as the official list of weldable parts in vessels building to the Society's classification.

Deck rail stanchions to plating.
Fastenings for detachable rail stanchions.
Joints of continuous railing rods.
Attaching deck collars (L-rings) around ventilators.
Attaching deck collars (L-rings) around funnel.
Attaching cape rings.
Attaching galley fixtures to plating.
Attaching bath and other fixtures in officers' quarters.

*Engineer, welded ship construction, member Society of Naval Architects and Marine Engineers, member American Bureau of Welding and American Welding Society.

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Attaching cowl supporting rings to ventilators.
Butts of bulwark rail.
Skylights over galley.
Engine room skylights.
Engine room stairs and gratings.
Boiler room stairs and gratings.
Attaching engine and boiler room stairs and gratings to plating.
All stairs and ladders, including rail attachments.
Door frames to casings, hinges, etc.
Clips for attaching cleating to casing.
Entire screen bulkhead.
Coal chutes.
Butts of water-tight and oil-tight boundary bars on bulkheads or floors in double bottom.
Ventilator cowls.
Funnels and uptakes.
Bulkheads (which are not structural parts of the ship).
Partition bulkheads in accommodation.
Framing and supports for engine and boiler room flooring or gratings.
Cargo batten cleats.
Tanks (which are not structural parts).
Hand rails on exterior and interior of deck houses.
Deck houses not covering unprotected openings through weather decks.
Reinforcing and protecting angles around manholes.
Joints of water-tight angle collars at frames in way of water-tight flats.

In their circular (No. 1328), it was specified that no restriction be made regarding the system of welding employed, providing the local surveyor be satisfied as to its efficiency.

Following the provisions embodied in their previous regulations concerning welding, it was further stipulated that proposals to weld electrically any other parts of a vessel should be submitted to their head offices for approval, with the intimation that such proposals would be, in general, "granted only provided the arrangements proposed are considered to be satisfactory, and the system of welding intended to be employed has been recognized by the committee as complying with the prescribed regulations and tests."

The foregoing list is now accepted by the classification societies and by shipbuilders generally as the official list which may be followed in the issuance of specifications for electrically welding parts of merchant vessels. It should be borne in mind, however, that even though electrically welded ships' parts may have been "passed" by their local inspectors or surveyor, such approval is regarded merely as a "tentative measure" for classification of the vessel in Lloyd's Register as "experimental" or "electrically welded." (See Section 74, Lloyd's Rules for 1919-20.)

As in the past, the United States Navy Department still follows somewhat different lines in its acceptance of welding, and its latest ruling in the premises, covered by Navy Department Letter No. 58520-z-124 of February 12, 1920, Bureau of Construction and Repair, embodies what may now be understood as the official list of permissible welding on ships for the Navy.

For convenient reference the various interpretations and classifications of items have been grouped under four headings, as follows:

First—*Welds Permitted Under Well Guarded Conditions.*
Welding thin to thick plates, as, for instance, thin flues to thick tube sheets.
Welding rigidly fixed members with little or no opportunity for expansion and contraction.
Welding together materials of different physical characteristics, as, for instance, mild to high tensile steel.
Welding accessory members to hull plating while ship is afloat.

Second—*Recommendations.*

8. It is generally recommended that welding operations be centered first on shop fabrication, leaving work on ship for secondary consideration.
9. That welds be confined, as far as possible, to tee or corner fillets. Also that lap joints be used in preference to butts.
10. That special care be given to the sequence of welding.
11. It is intended that where welding is desired on new construction, it must be shown on plans, definitely marked, and covered by note to insure criticism in connection with approval of plans.

Third—*Welding Not Permitted.*

12. Welding shapes, plates or fittings to high tensile or special treatment steel members.
13. Welding high tensile steel members to each other.
14. Welding special treatment steel members to each other.
15. Welding in transverse lines, i. e., transverse members to longitudinal members, whether of medium steel or not.
16. Welding plates which form bracket plates, as, for instance, split bulkhead stiffeners.
17. Welding awning and rail stanchion feet to deck. (See item 48 for stanchion fittings.)
18. Strength members in general.
19. Welding any longitudinal strength member, such as:
Stringer plates.
Stringer angles.
Longitudinal angles.
Longitudinal and vertical keel angles.
Longitudinal bulkhead angles.
Butts of longitudinal plating, such as longitudinals, shell, deck and stringer plates.
20. Emphasizing item 18.

Fourth—*Welding Approved by the Bureau of Construction and Repair for New Construction.*

23. *Heading: Doors, Hatches, Manholes, Skylights, Air Ports, etc.*
24. Handles for doors, hatches and manholes.
25. Hinge, hook and brake pads for doors, hatches and manholes.
26. Flanged retaining bar for rubber gaskets for doors, hatches and manholes.
27. Stiffening angles for doors, hatches and manholes, provided these angles are cntinuously welded at their ends, where same butt against bounding angle of the floor or hatch cover.
28. Non-watertight doors, frames to bulkheads.
29. Engine room skylights, except attachment to deck.
30. Window frames.
31. *Heading: Miscellaneous Fittings for Storerooms, Compartments, etc.*
32. Miscellaneous clips to decks and bulkheads, such as stowage members, mess table attachments, etc., all subject to limitations prescribes in items 11 and 19.
33. Bathroom attachments.
34. Galley fixture attachments.
35. Gratings.
36. Pipe hangers, where applicable.
37. Ash hoppers.
38. Ladders.
39. Pads, grab rods, lacing hooks or eyes.
40. Ammunition racks.
41 Storeroom shelving.
42. Drain wells.
43. *Heading: Hatches.* (See item 23.)
44. *Heading: Manholes.* (See item 23.)
45. *Heading: Piping.*
45. Low pressure built up steel pipe and fittings, including drainage system.
46. Ventilators, cowls and ducts.
47. Watertight and non-watertight ventilation piping.
48. *Heading: Stanchions, Deck, Awning, Rail, etc.* (See item 17.)
49. Hooks on awning, rail and life line stanchions.
50. Head casting on awning stanchions to carry awning rope.
51. Structural:
52. Butt welding transverse bulkhead bounding bars in lieu of joggled bars or bosom bars. Above subject to following conditions:
53. First—Longitudinal strength bulkheads are wholly excepted.
54. Second—Where double bounding bars are fitted, butts of opposite bars must be well staggered.
55. Third—Bounding bars of watertight floors in double bottoms are wholly excepted.
56. Seams and butts of bulkhead plating, when bulkhead is of light or non-watertight construction.

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57. Stiffeners to bulkhead plating conditional as under item 56.
58. Channels, built up from angles and flats.
59. Minor foundations.
60. Torpedo tube foundations, except attachment to deck.
61. Deck houses.
62. Air locks.
63. Flanged or dished plate corners.
64. Range finder platforms.
65. Searchlight platforms.
66. Pocket recesses.
67. Angle ring butts.
68. Welding stiffening rings to plates for bolting covers over openings. (This subject to approval of superintending constructors.)
70. Fabricating plate and angle staples.
71. Swash plates.
72. Hatch trunk butts.
73. Pipe tunnels.
74. Shaft tunnels.
75. Wiring tunnels.
76. Windshields.
77. Miscellaneous.
78. Attachment of half rounds, half ovals, etc.
79. Welding splice plates to angles to increase width of latter for attachment of fittings for tightness rather than strength.
80. Tanks, lockers, etc.
81. Stowing boxes for cleaning gear.
82. " " " flag.
83. " " " life preserver.
84. Chutes, such as coal and slop.
85. Ash hoppers.
86. Bread lockers.
87. Miscellaneous lockers.
88. Vegetable lockers.
89. Tanks, separate, up to 10 pounds pressure.
90. Tanks, gravity, for fresh water.
91. Transoms.

Like many other worthy movements the welding art has suffered most at the hands of its friends. Unfortunately for the best interests of welding many of its more enthusiastic advocates have urged the building of structures much beyond the proper capacity of their organization and equipment. The use of spot welding for fabricating the heavier framing members of ships appealed very strongly to certain of the builders engaged on work for our merchant marine, but it is very doubtful if the salvage value of the remaining scrap equipment will reduce the cost of those experiments to $100,000.

The persistence with which the 10,000-ton electrically welded ship was exploited called for exceptional reserve on the part of the Emergency Fleet heads who had to account for the millions being expended for ships, and who, fortunately, had practical knowledge of the uncharted rocks in the course of new ventures.

Making haste slowly has proven particularly beneficial in the development of this new method of ship construction, for it has enabled builders gradually to readjust their personnel and accumulate sufficient mechanical equipment for its proper conduct.

These have been very necessary preliminaries which, fortunately, are now accomplished; and there appears to be nothing in the way of attempting the larger problems provided, of course, the constructor has a well-organized welding plant and a sufficient number of competent, conscientious welders to carry out the work promptly.

Repairing Ships by Thermit Welding

THE value of thermit welding in connection with realinement and other general utility work on large marine castings, in addition to its more frequent use in repairing fractured stern frames, rudder frames, etc., is well demonstrated in the case of two unusual thermit welding repairs recently made at the Brooklyn Navy Yard, New York.

Figs. 1 and 2 show an interesting double weld made on the cast steel rudder head of the steamship *Leopoldina* (formerly the *Blucher*), belonging to the Compagnie Générale Transatlantique. The whole purpose of this job was to repair the rudder stock, the upper part of which had to fit into a key-way on the rudder head. In order to make the repair it was first necessary to remove the rudder stock from the rudder head. The two sections, however, had become so tightly locked together that it was finally decided to separate them by cutting through one side of the

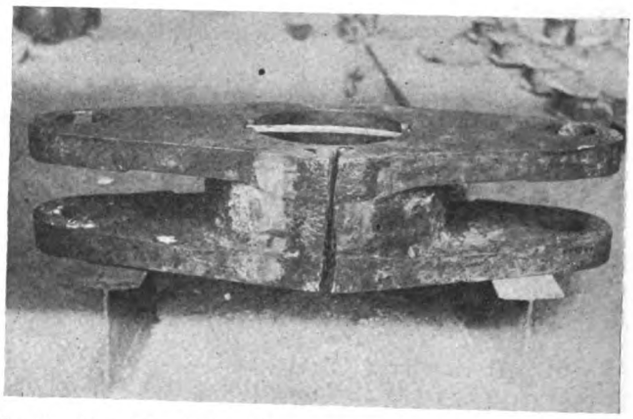

Fig. 1.—One Side of Rudderhead Partly Cut Out by Oxy-Acetylene Torch

rudder head with an oxy-acetylene torch. The rudder head was then removed.

In repairing the rudder head it was necessary to cut through the side opposite the first oxy-acetylene cut in order to make two welds instead of one, and thus later equalize the effect of contraction when the welds had cooled. Having done this the two parts were lined up together so as to leave small gaps at the oxy-acetylene cuts.

A yellow wax pattern was then applied to the space formed by the gap and shaped around the adjacent por-

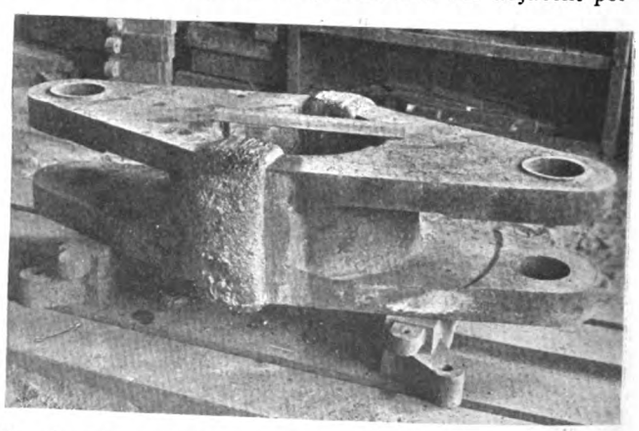

Fig. 2.—Thermit Welds on Rudderheads After Removing Risers and Pouring Gates

tions of the casting in the form of a collar. The next operation consisted of building a mold around the wax pattern and then burning the wax out of the mold by means of gasoline (petrol) torches. The gasoline (petrol) flame also served to preheat the parts of the casting near the welds, in order to provide a more uniform contraction when the welds cooled.

As the position of the pouring gate steel shows in Fig. 1, both welds were poured simultaneously, using 350 pounds of thermit. Excellent welds were obtained and the cross-

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head quickly returned to service. It is interesting to note that, as this repair was urgent, only 9 to 10 hours of working time were required to complete the welding operation.

Fig. 3 shows a thermit weld made on the starboard propeller strut of the United States torpedo boat destroyer *MacDougal*. This work was remarkable for the accurate allowance made for the contraction of the weld. The cast steel lower leg of the strut had been forced and elongated outward from the side of the ship, so that the

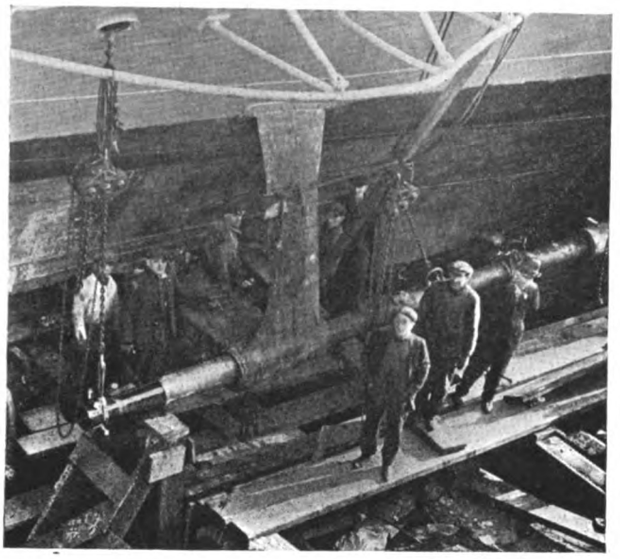

Fig. 3.—Thermit Weld on Propeller Strut of United States Destroyer *MacDougal*

propeller shaft bearing was ½ inch out of alinement. To remedy this defect a small section was cut out of the lower leg of the strut, so that it was shortened the required amount. The two sections of the lower leg were then reunited by means of the thermit process. The section welded was 3 inches thick at its thickest part and 22 inches wide, and required 200 pounds of thermit.

Automatic Arc Welder Developed by the General Electric Company

AUTOMATIC arc welding is now accomplished by a new device prefected by the General Electric Company, Schenectady, N. Y., and soon to be put on the market, which is known as the automatic arc welder. This welder, for use with the regular welding set, is designed to take the place of the hand-controlled electrode. It consists of a pair of feed rollers, called feed rolls, driven by a small direct-current motor, which draw in and deliver to the arc a steady supply of wire, and automatically maintain the best working distance. The whole is controlled from a small panel.

The welding head is held by a suitable support with a certain amount of hand-regulated adjustment, and consists of a steel body carrying feed rolls and straightening rolls, which are both adjustable for various sizes of wire. The arm is supported on a gear box, together with the motor. This box contains gears which give three gear ratios, thus extending the range of the device while allowing the motor to operate at its most favorable speed.

The control panel carries an ammeter and voltmeter for the welding circuit, as well as rheostats, a control relay, and the contactors and switches for the feed motor. It is possible to start and stop the equipment from the work

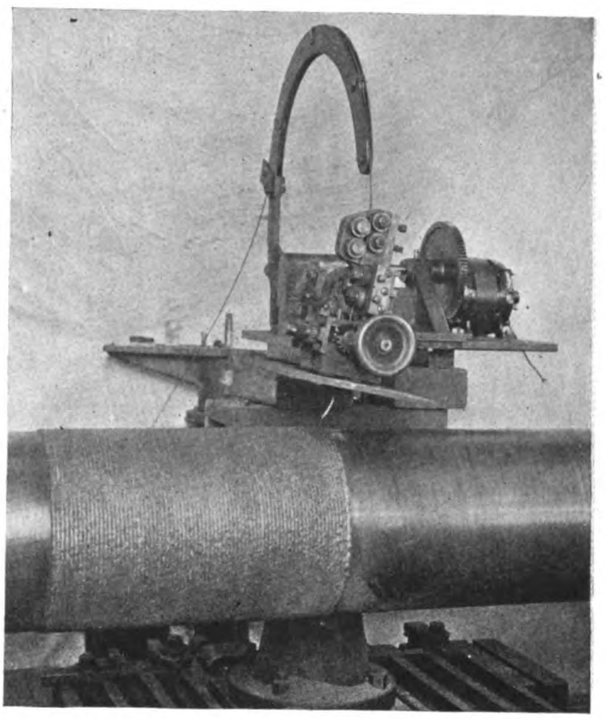

Fig. 1.—The Automatic Arc Welder Building Up 14-Inch Shaft to ⅜-Inch Increase in Diameter. One of Many Functions Which This Device Can Perform

by a pendant push button, but adjustment of the feed conditions must be made from the panel.

The adjustment for arc conditions by regulation of the speed of the feed motor, as the arc voltage varies, is taken care of by the panel equipment. The result is a practically steady arc, which is greatly superior in smoothness of operation to any hand-controlled arc, consequently increasing the speed of the welding.

The whole apparatus is mounted on a base which can be bolted to any form of support. Thus a great variety of working conditions can be met, but provision must be made for carrying the arc at uniform speed along the weld. For instance, for straight seams, a lathe or planer

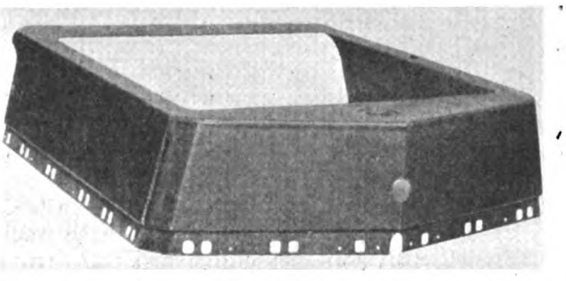

Fig. 2.—Radiator Cover of No. 19-Gage Metal (.044-Inch Thick), Welded With Metallic Electrode by Automatic Arc Welding Process

bed may be used, and for circular ones a lathe or boring mill. However, the local conditions will dictate the method to be followed.

The device is especially valuable where a large amount of routine welding is to be done, since it is capable of from two to six times the speed possible to skilled operators, and gives a uniform weld of improved quality. It is adaptable to welding seams of tanks and plates, rebuilding worn or inaccurately turned shafts (as shown in the illustration), rebuilding worn treads and flanges of wheels, and many other kinds of work.

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A New Development in the Application of Electricity to Marine Transportation

Electrical Power Generated On One Vessel Transmitted to Another Vessel for Propulsion and Other Uses—Tests Prove Practicability

BY WILLIAM T. DONNELLY*

IT is almost exactly five years ago that I contributed to this journal (see MARINE ENGINEERING, May and June, 1915) a paper entitled "Application of Electricity to Propulsion," which described the electrically propelled yacht *Dawn*, and gave not only complete and accurate plans of that boat and the electric power generating and propelling machinery, but also foretold the construction and operation of the present vessel the *New Era*, the building and operation of which are described in the following pages:

My comprehension about that time of the familiar sight of one vessel towing another was in reality, from an engineering point of view, much more than we had realized; it was in fact a means of transmitting power from one vessel to another, but with very great limitations. In other words, the power transmission, while complete, was limited to the possibility of moving the vessel towed only in one direction and only in a straight line.

My invention, as outlined five years ago, showed how electric power generated on one vessel and transmitted over a flexible cable could be used not only for propulsion, but for all other purposes. It goes without saying that at that time I believed that the disclosure of this invention and engineering information in connection with it would lead to its development and application, but in spite of the fact that for five years I have used every means of bringing it before all parties who should be interested in such an undertaking, nothing whatever was done so far as I have been able to learn by anyone else to bring into existence the invention outlined and illustrated.

While this may seem to many strange, and to others an indication of the impracticability of the invention, it appears to me as neither of these but only an illustration of the inertia in the progress of human affairs.

TARDY ADOPTION OF NEW INVENTIONS

A careful research and study in the development of any of our arts will show a similar hesitancy or loss of time between their presentation and the beginning of their adaptation. The original application of mechanical power to marine transportation waited a much longer time; as a matter of fact Robert Fulton spent more than ten years of his life endeavoring to find someone who would become interested with him in the application of steam power for the propulsion of vessels afloat, and in this quest searched Russia, England and France, finally returning to America, where he succeeded in finding one man, Robert Livingston, who would agree to provide half the funds to construct the *Clermont*.

I myself, after waiting five years, have been fortunate enough to be able to finance the undertaking of turning my ideas and inventions as set forth in the paper previously referred to into actual concrete-working form, and the paper herewith presented is for the purpose of recording and presenting the result of the construction and operation of a companion vessel furnished with power and operated from the power plant of the *Dawn* as originally built without modification or addition.

* Consulting Engineer, 17 Battery Place, New York.

The *New Era*, as the second boat is called, was laid down in the same yard as her predecessor. The name of the builder, however, has been changed from Hehre & Auer to the Dawn Boat and Shipbuilding Corporation, a compliment to the success of the previous boat, and before taking up the description of the *New Era* I should like to record here briefly some facts relative to the intervening history of the *Dawn*.

SERVICE RECORD OF THE DAWN

In the summer of 1916 the *Dawn* made a cruise through long Island Sound, visiting New Haven, New London, Fall River and Providence, and many smaller ports, covering a distance of 700 miles, and proved herself to be an ideal home for my family of five; and at each port short trips were enjoyed by my friends.

When in the early part of 1917, it became apparent that the United States must take a serious part in the world war, the use of yachts and motorboats for harbor defense was at once taken up by our Government. The result was that the *Dawn*, under the command of my son, entered the Scout Patrol Service as *S. P.* 26, and served through the summer of 1917 and the winter of 1917-18, patrolling off Newport Harbor.

The *Dawn* was returned to me in the summer of 1918, and I can assure you that she bore marks of the ravages of war, and it was only by the expenditure of a very considerable sum of money that I was able to turn her back into a yacht by the end of that season. I would like to say, however, that the electric power plant stood the struggle in a very remarkable manner, the only replacements or renewals being of small engine parts. It will be understood that the power furnished to the *New Era* from the *Dawn* for the cruise, which I am to describe was by the original power plant as described in the previous paper.

BUILDING THE NEW ERA

To return to my description of the *New Era*, the work on this vessel was commenced in the winter of 1918. The lines laid down were the same as those for the *Dawn* with, however, an increased freeboard and a rearrangement of the forward cabin, the increased freeboard forward providing for a flush deck. The power plant, of course, was entirely eliminated. An electric motor for propulsion, of 20 horsepower, the same as on the *Dawn* was placed in identically the same position below the floor of the forward cabin, as will be seen from the illustration. This leaves the entire cabin space of the *New Era* free of all machinery. The pilot house or forward cabin has the usual wheel, and before it the control board.

A HOME AFLOAT

As the *New Era* is primarily built for a home afloat, I will first describe the features which pertain to this part of the undertaking, and as the food supply is the most essential part of a home, we will commence with the galley. The galley is aft on the starboard side, arranged in the same general manner as upon the *Dawn*. An ice

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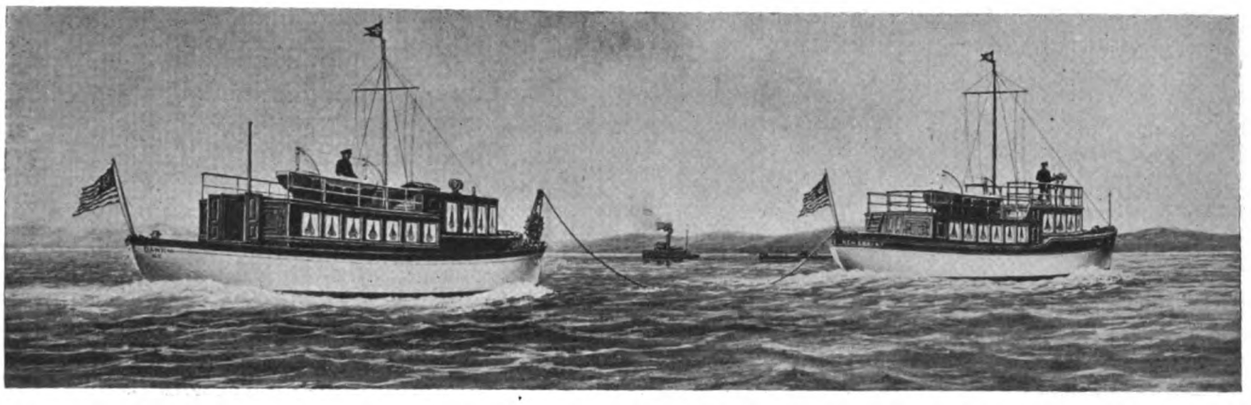

Fig. 1.—Power Boat *Dawn* Supplying Electric Current for Propulsion of the *New Era*

chest of unusual proportions and fully equal to anything found in a private home is provided and arranged in such a manner that ice can be introduced from the deck outside. Ample provision is made for the storage of eatables both fresh and tinned, also closets for the care of dishes. The water supply is under air pressure, and this feature is exactly the same as in any home. Cooking is done by electric stove, the electric supply coming from an ample storage battery at 110 volts so that standard electric-cooking appliances can be used.

In the cruise which I am to describe, toast was made on the table at every meal, and all coffee was made in an electric coffee percolator.

Living Quarters

The after cabin is approximately 9 feet wide by 12 feet long, and the usual transoms or seats are entirely missing. At the starboard side there is a davenport of ample proportions, which makes during the day a very fine couch, and at night turns into an excellent double-width bed. Forward of this on the starboard side is a closet of ample proportions to hold wraps on coat hangers. Forward, in the center is a combination dresser with bevelled mirrors. Toilet arrangements are provided in two locations aft, and washing facilities in the forward cabin and at two places connected with the after cabin. It will be understood that both fresh and salt water are under pressure, and all plumbing and water fixtures operate exactly as in a house on shore. This is brought about by having round-water tanks and introducing air pressure above the water by an automatic air compressor operated by electricity.

The pilot house or forward cabin is approximately 9 feet by 10 feet, and has across the after end a davenport similar to the one in the after cabin. This is also of

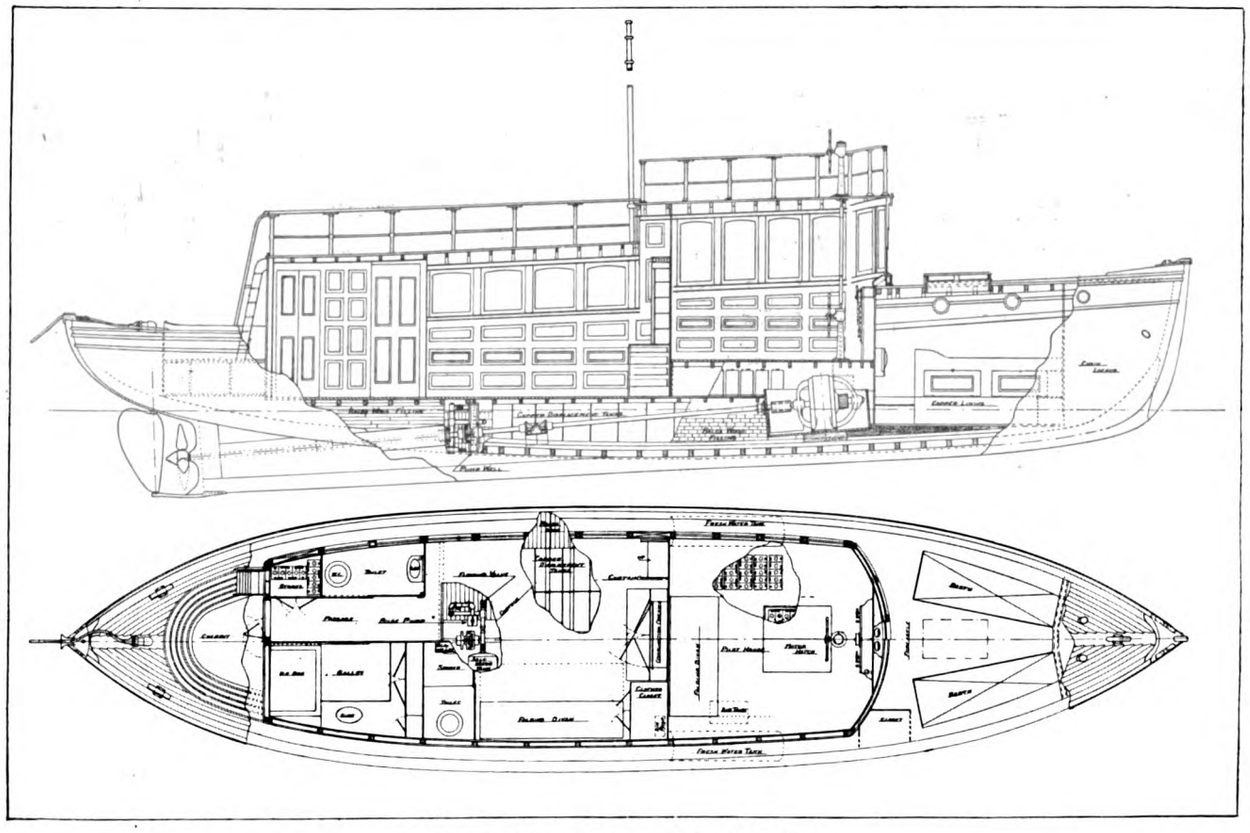

Fig. 2.—General Plans of the *New Era*

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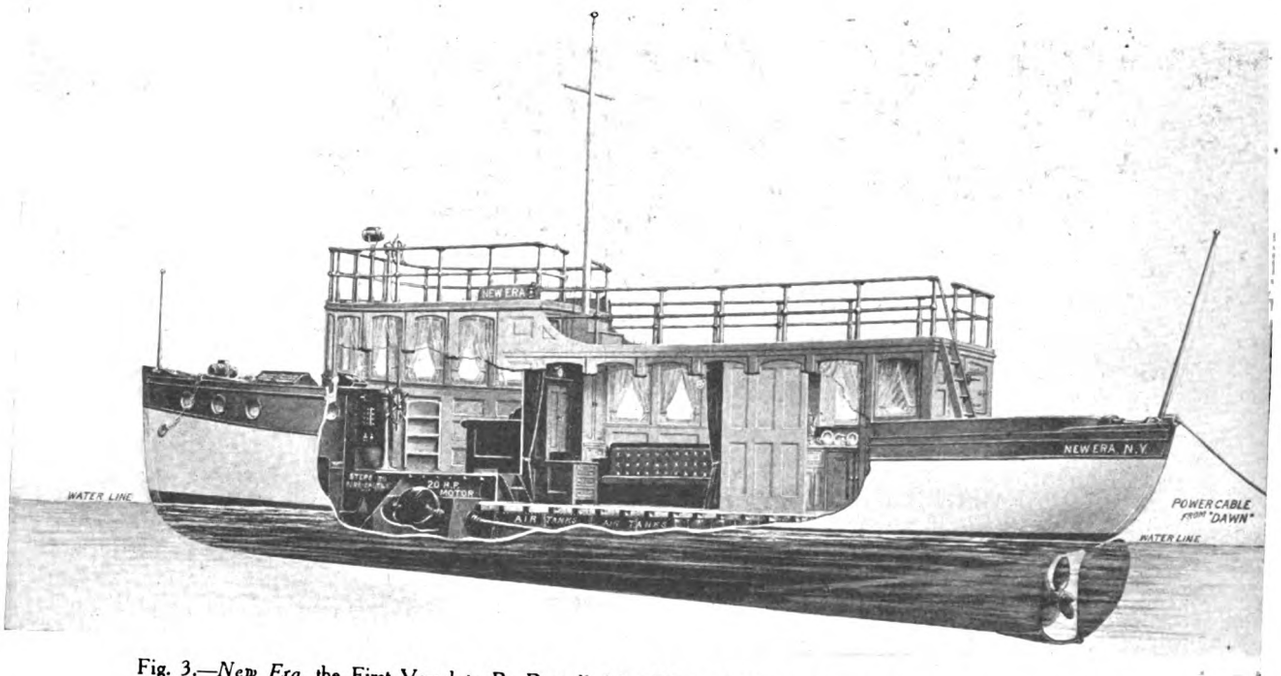

Fig. 3.—*New Era*, the First Vessel to Be Propelled by Electrical Power Generated on a Convoying Vessel

dimensions corresponding to a full-size double bed, in fact both davenports are of standard design intended for use in private homes.

Under the forward deck there are two berths of ordinary ship construction where beds are kept made up. These are fitted in the very best manner with box springs, and all the usual details. Ample locker space is provided throughout.

The lighting is by electric lights supplied with current at 110 volts, by concealed wiring installed according to underwriters' regulations precisely the same as in the best class of private dwellings.

The *Dawn* was built with a flush deck aft, but the *New Era* has a cockpit aft, which makes a more ready access to the cabin and avoids the necessity of cutting the deck.

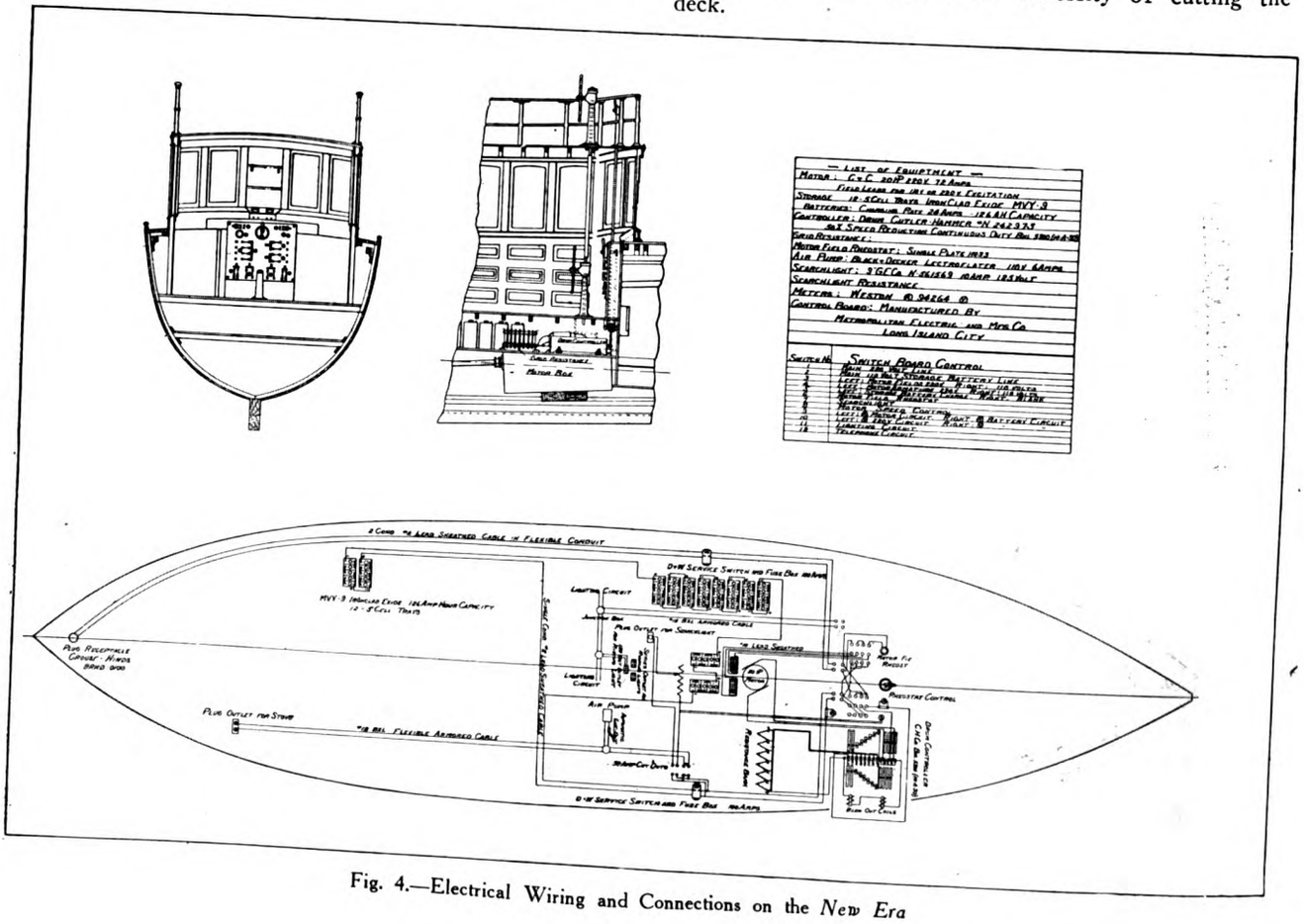

Fig. 4.—Electrical Wiring and Connections on the *New Era*

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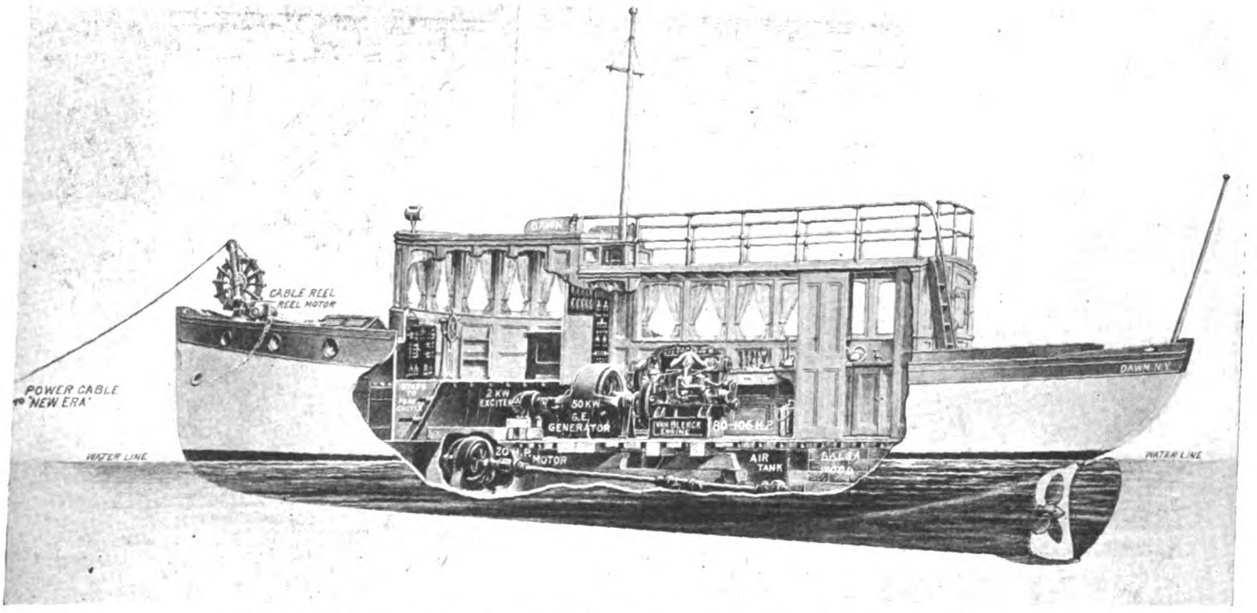

Fig. 5.—Electrical Power Generating Plant and Propelling Machinery on the *Dawn*

NON-SINKABLE CONSTRUCTION

Perhaps the most remarkable feature about the *New Era*, and one which was not contemplated when the previous paper was written is the non-sinkable feature. For many years the non-sinkable and even non-capsizable lifeboat has been well known, but, for reasons which it is hard for the ordinary mind to understand, the development of this feature of floating craft has never been applied to other vessels. So far as I am aware this is the first time that an attempt has been made to render a power yacht of any considerable dimensions entirely safe against sinking. This has been accomplished by placing the floor of the cabin 6 inches above the waterline, and then filling in all vacant space below, first the irregular parts with Balsa wood (a tropical wood lighter than cork), and then the remaining space not occupied by machinery or necessary parts for the boat, by air-tight copper tanks exactly similar to those used in lifeboats.

Of course, in the carrying out of any principle whatever in a physical structure, perfection is never reached, and

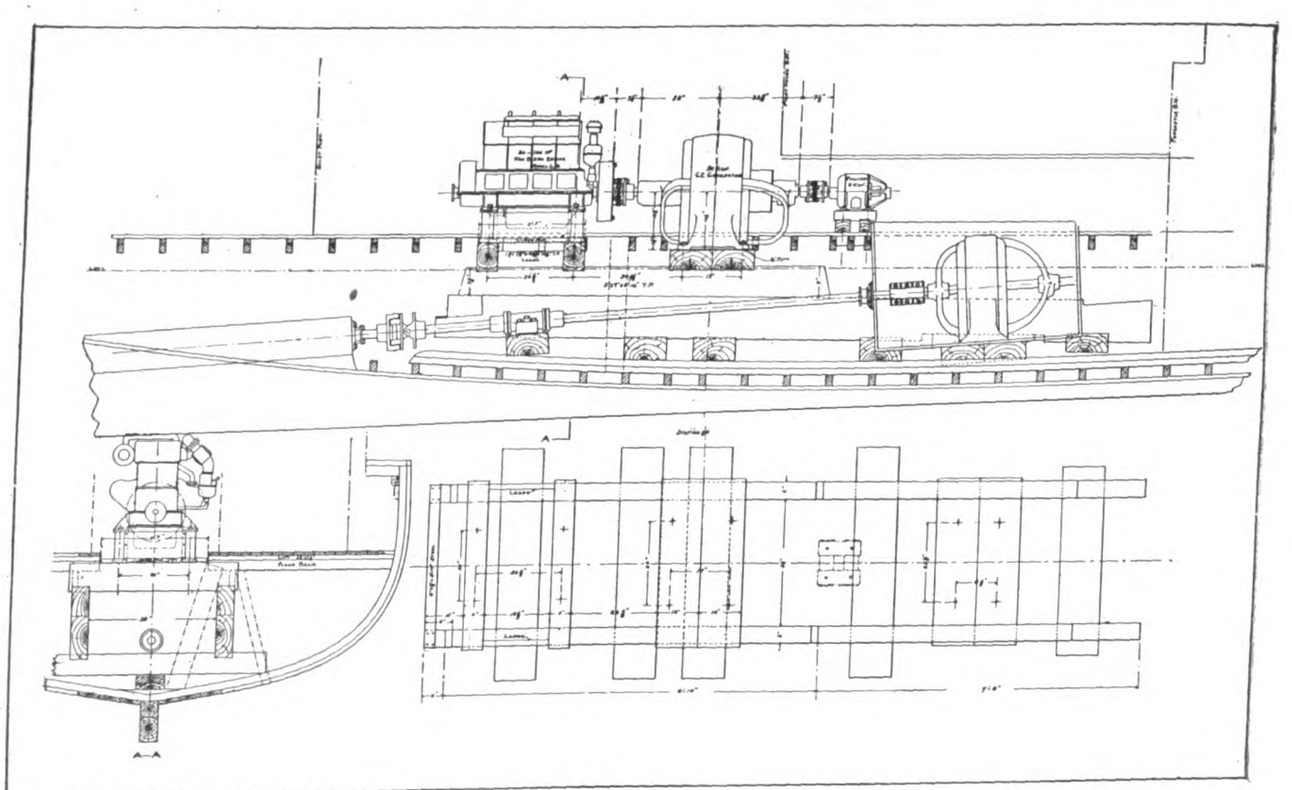

Fig. 6.—Machinery Arrangement of the *Dawn*

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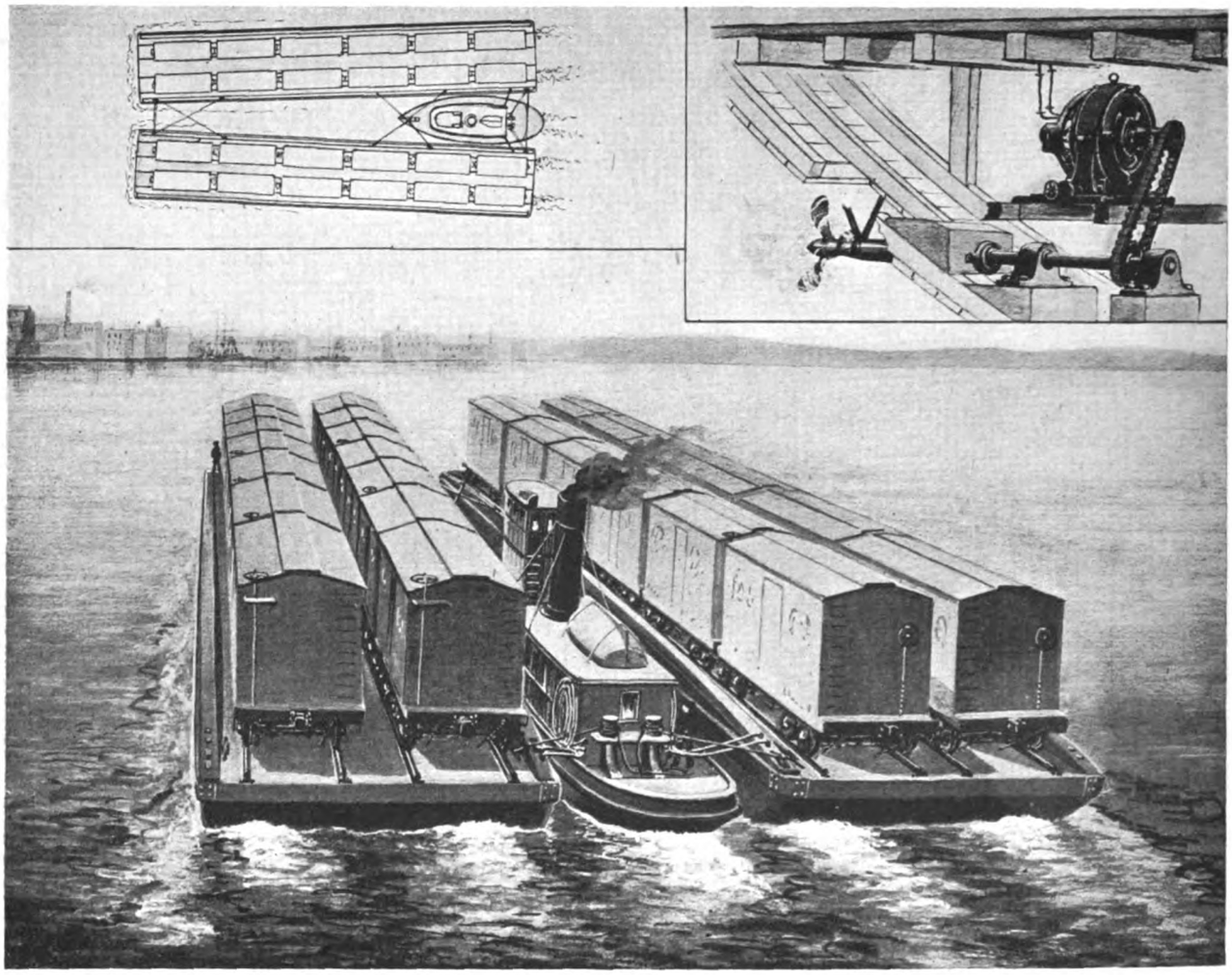

Fig. 7.—Proposed Arrangement for Electrically Propelled Car Floats

it is not possible to occupy every particle of space below the waterline, but it is practical to occupy so much that when water is freely allowed to enter it will be in such a limited quantity that the increased draft of the boat will be a very small amount. In the *New Era* it is actually less than 2 inches, that is, when all leakage is pumped out of the *New Era* and the draft carefully noted and subsequently a hole is opened in the bottom, provision for which is made in the construction of the boat, and water allowed to enter freely, the increased draft of the boat, when the level of water inside and out is the same, is not more than 2 inches. In other words, the boat does not settle far enough for the water to come above the cabin floor, and no fixtures or fittings of the boat are damaged.

The importance of this feature cannot be over-exaggerated. It gives one first, and particularly our ladies whom we like to have with us when yachting, a sense of security which cannot be obtained in any other manner. It gives to us, who put a very considerable amount of money into the building and fitting up of such a floating home, a very great sense of security that we may continue to enjoy our investment for a very considerable period of time.

Cost of the Non-Sinkable Construction

As soon as one is convinced of the possibility of rendering a boat non-sinkable, the mind is crowded with the question, "How much does it cost? Can anyone afford to build a boat that way?"

Having kept a careful record of the cost of rendering the *New Era* non-sinkable, I am prepared to state that it is comparatively such a small amount that the saving in insurance on the value of the boat for one year will approximately recompense the owner for the necessary expenditure. In other words, money so invested pays 100 percent annually on the investment plus all the insurance and satisfaction which come from having a lifeboat under your feet as well as a summer home. The saving in insurance is the difference between the ordinary marine risk, which covers sinking and carries a premium of 5 percent per annum, and insurance against destruction by fire, which is covered by 1 percent.

Electrical Transmission Apparatus

Taking up the engineering or technical side of the practical application of electricity to marine transportation, the *New Era* is provided with a 20 horsepower motor. The electric current is received from the generating plant of the *Dawn* through a flexible water-proof cable. A reel is provided on the bow of the *Dawn* and the manner of connecting current to the cable will be clearly understood from a study of the plans accompanying the paper.

The separate conductors are led to opposite ends of the axle, or bearing of the reel, and introduced into the hollow axle by suitable plugs. The cable itself is of the well-known concentric construction, that is, an outer and inner conductor separated by insulated material, the outer conductor being again insulated and protected by jute covering. The cable for the transmission of 20 horse-

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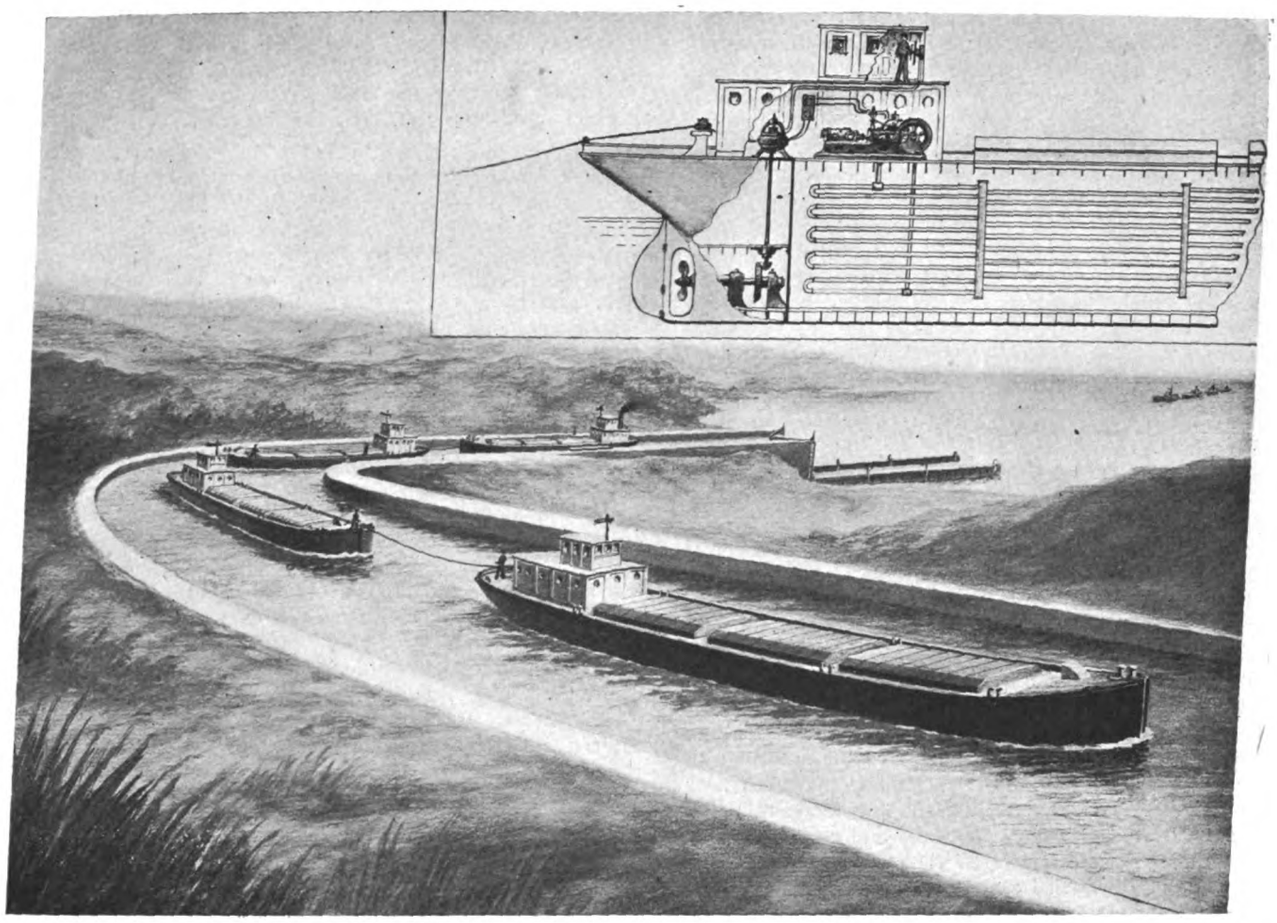

Fig. 3.—Proposed Arrangement of Electrically Propelled and Refrigerated Canal Barges

power at 220 volts is slightly less than 1 inch in diameter, and weighs approximately ½ pound per foot. One hundred feet of this cable was provided, and during the trip to be described about 60 feet of cable was used between the boats, this with the drop or sag of the cable spacing the boats about 50 feet apart.

The cable comes in over the stern of the *New Era* through a special bronze bell-shaped casting. Just inboard from this bell there is attached a line which is led to a convenient cleat for taking the pull due to the weight of the cable. The slack of the cable is then run to an annular plug directly over the rudder post and passes down through the deck, after which the conductors are separated and carried through metal conduit to the switchboard and motor at the forward part of the pilot house. The details of all electrical connections are shown in Fig. 4.

Storage Battery Provided

Besides the connection to the electric motor, provision is made for connecting through proper resistance to an iron-clad storage battery with 60 cells, capable when fully charged of delivering something over 120 volts. The storage battery has a capacity for propelling the boat, when disconnected from the source of power, at a speed of approximately six miles an hour for two and a half hours, it being understood, of course, that in regular cruising all power for the propulsion of the *New Era* is delivered directly from the generator on board the *Dawn* to the motor on board the *New Era*, and in the meantime electricity previously supplied to the storage battery can be used for lighting, heating, cooking or any other purpose.

The 20 horsepower electric motor propelling the boat is operated through a controller introducing resistance into the armature circuit in the usual manner. This controller is placed under the forward cabin floor, as may be seen by referring to Fig. 4, and is of the ordinary rotary type manipulated by engine-room telegraph transmission. The resistance provides five different speeds in either direction.

The mechanical arrangement of the steering and control is such that the boat can be controlled either from the wheel house or directly above on deck.

Propelling Motor Located in Watertight Compartment

Referring to the motor and its location under the floor of the wheel house, it will be apparent that this motor occupies a considerable space below the waterline, and also that water must be excluded from contact with electric parts, such as brushes, etc. To accomplish this, the whole motor is placed within a watertight box made of wood and lined with copper, not on the inside, but on the outside of the box so that the water entering the boat can rise around the outside of this box but cannot come in contact with the motor.

Novel Thrust Bearing

Referring to the transmission shaft from the motor to the propeller, there will be seen a thrust bearing, which it will be understood is of identical construction to the one which was applied to the *Dawn*. This is of very unusual construction, as it is a plain friction bearing and runs entirely without lubrication. The one on the *Dawn* has been running more than five years, and has never been lubricated and does not show any appreciable wear.

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Aft of the thrust bearing is a flexible connection of special design, also the same as in use on the *Dawn*, which is very desirable, as it eliminates the necessity of maintaining accurate alinement of such a long transmission shaft. The *New Era* is also supplied with a powerful arc searchlight, which is not only of very real use at night, but a source of very great satisfaction and entertainment during summer evenings.

Besides the electric cable transmitting power, we have a telephone cable connecting the *Dawn* and the *New Era*, and at all times it is entirely practical to communicate with your power plant and crew on the other boat.

Electricity Adds to the Joy of Living Afloat

To speak of the *New Era* as an entirety, I find, is very difficult. To have an electric power generating plant within almost arm's reach supplying electricity in practically unlimited quantity, so far as your necessity is concerned, puts the whole question of life upon the water and its enjoyment upon an entirely new plane. The elimination on the yacht of the power plant, crew, fuel, stores and a thousand and one things which must go with you to make life desirable, let alone enjoyable, far from home and out of contact with all sources of supply, is something almost beyond the dream of man, but here it is accomplished.

Try and comprehend a home combining means of transportation in almost any desired direction, to almost any city, which comprises every convenience that you have known in the matter of light, heat, sleeping, cooking, and all other facilities, also provides employees within arm's reach at your call by telephone at any moment, and at the same time eliminates a thousand and one cares which the ordinary immovable home throws upon you. These and many more which I cannot enumerate await the complete and comprehensive application of electricity to marine transportation.

Materials Used in Construction

While the plans for building the *New Era* were well worked out in advance, those which appertain to making the boat non-sinkable were entirely new, and progress was necessarily slow. Besides this the endeavor was made to spare nothing in the matter of quality of materials and workmanship. The wood entering into the structure was very carefully selected. The frames, keel, stem and stern are of selected white oak, the planking below the waterline of cedar, and above the waterline of Oregon fir in very long lengths. The sheer streak and upper work are of mahogany, the deck and rail of very carefully selected teak wood, the cabin throughout of Mexican mahogany, and the interior panelling work in selected wood and finished in the most careful and thorough manner.

Since yachts have been made, brass or iron railing has been almost exclusively used. To me they have always been a source of annoyance. Brass rail can never be kept polished, and the iron rail always appears to be quarrelling with every other details of the boat. On the *New Era* a departure was made in designing and building the entire rail of mahogany to harmonize with the rest of the boat, and the result has been more than satisfactory. It will be seen that the railing is placed around both the after and forward cabins. The beam of the *New Era* is such as to give more than satisfactory stability with any number of people on the deck of the pilot house. It will be understood that provision is made for awnings in the summer time, although not shown on the plans:

To take up the actual operation of the *Dawn* and *New Era* in convoy, the *New Era* was launched on October 18, 1919, and finally completed on October 31, 1919. The trial trip was from Clason Point to Bayside Yacht Club, Little Neck Bay, Long Island, and proved an entire success.

The Cruise Up the Hudson

On November 3 the boats left Bayside Yacht Club in convoy for a cruise to Schenectady, N. Y. by way of the Hudson River and the New York Barge Canal. The trip down the East River and up through the Harlem River, under and through all the bridges, was made without the slightest difficulty, it being found entirely practical to control the speeds of the two boats, so that the connecting power cable, telephone cable and the light manila line were slack at all times. The first stop was made at Hastings, at 4 p. m., November 3; and the next day the run was made to Ossining and a stop was made for gasoline (petrol). The party on board the *New Era*, consisted of three others besides myself, and on board the *Dawn* were the engineer in charge of the power plant, an electrician and a deck hand.

At Ossining the two boats weathered a severe winter storm, lasting thirty hours, during which the boats were in danger of being driven on a lee shore, but disaster was averted by utilizing the power available from the storage battery. After recovering from this experience, the cruise proceeded northward with delightful weather. A night was spent at Poughkeepsie, and another at Kingston, where the voyage was delayed a day or two on account of thick weather. Leaving Kingston at 12:30 o'clock in the afternoon of November 12, we reached Albany at 7:30 p. m., after dark in a rain storm, separated the two boats below the bridge, took the *New Era* through under her battery power with the aid of the searchlight, and were followed by the *Dawn*, each boat making its own landing at the public pier, where we remained overnight.

The next day we proceeded to Troy and passed through the first lock on the Hudson at that place. This was our first experience with the two boats together entering a lock. We ran in together with two tugboats just ahead, and found not a particle of difficulty, the boats handling as readily and as quickly as the separate tugboat.

Practical Demonstrations

On the morning of November 14, we were joined by four representatives of the General Electric Company who proceeded with us through the flight of locks at Cohoes, which give entrance to the Mohawk River. This flight of six locks, together with the one on the Hudson raised us to an elevation of almost 200 feet above sea level. Lock No. 8 below Schenectady, raised us to a final elevation of 211 feet. Not a particle of difficulty was experienced in maneuvering in and out of any of these locks.

We arrived at Schenectady at 5:18 p. m. Where the *Dawn* and *New Era* were inspected by engineers of the General Electric Company. On November 17, a demonstration trip was made up to and through Lock No. 8, returning to Schenectady.

On the return trip we left Schenectady at 10:30 a. m. November 19, and were down through the last of the locks and into the Hudson at Waterford by 4 p. m. Coming out of the last lock into the Hudson the power plant of the *Dawn* gave trouble by a stripping of the teeth of the rawhide gear driving the exciter from the main generator, and supplying current for separate excitation of the field of the generator and motor of the *Dawn*. This was a definite tieup, but with quick work I was able to leave within two hours with the gears to be turned and re-cut at Schenectady, through the courtesy of the Geneneral Electric Company, and we were able to get the

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gears finished and returned the next day, after which we proceeded on our way to Albany.

At Albany we tied up at the Albany Yacht Club, and on November 22 made a demonstration run up the river with the superintendent of Public Works of the State of New York, and one of his engineers. The two boats worked perfectly together, turning under full speed and showing perfect freedom of movement, that is, it would be practically impossible to tell that the *Dawn* was being followed by another boat, if one did not turn around to look for it.

Particular attention was called to the fact that the operation of the motor for propelling the *New Era* was perfectly silent and no vibration whatever could be detected. In other words, the *New Era* worked smoothly under perfect control without any apparent means of propulsion.

Leaving Albany on November 23, we made a leisurely trip down the Hudson, returning via spuyten Duyvil and the Harlem River to our winter quarters at Clason Point at 2:15 p. m., November 27.

Improvements for the Dawn

The power plant of the *Dawn* which accomplished this work was gotten together something more than seven years ago. Since then the gasoline (petrol) engine and all things appertaining to it have advanced rapidly, and the accompanying plans of the *Dawn* show the reconstructed power plant which is now being installed, also an auxiliary set of 4-kilowatt capacity, which is to be used for charging storage batteries, lighting, cooking, etc., when at anchor. This set will deliver 4 kilowatts for one hour on the consumption of a little less than a gallon of gasoline (petrol). This means 4,000 watts of electricity for approximately 27 cents. It is generally considered that 600 watts is sufficient to operate an adequate electric-cooking apparatus. Allowing 1,000 for each boat, it is very plain that we will be able to cook on both boats at the same time for an hour for an expenditure of approximately 27 cents for fuel. What more can anyone ask in these times of high cost of living?

This has been rather a full explanation of the practical application of electricity from one boat to another for yachting or recreation sailing, which to me is the sport of all sports, and the nearest thing we know of to an ideal home, not only on the water, but in transit from one city to another.

Broader Application of Electricity to Marine Transportation to Come

The broader application of this method of applying power has now been definitely taken up, and as time goes on I will be able to describe first its application to barge and canal work, and beyond that to passenger vessels, and eventually to all water-borne commerce.

The practicability of this means of distributing and applying electricity has been proved beyond question. There now remains the distribution of the knowledge and the training of others in the art of its use.

The Broady Collapsible Lifeboat

THE International Conference on Safety at Sea divided standard lifeboats in two classes—those with rigid sides, called Class I boats, and those with partially collapsible sides, or Class II boats. Both classes were subdivided into three sections and under section *A* of the second class was specified an open lifeboat with the upper part of the sides collapsible; this type calls for buoyant fenders. Sections *B* and *C*, under Class II, cover pontoon boats with a well or flush deck.

Fig. 1.—Broady Lifeboat with Sides Collapsed

The rulings laid down at the time require that a certain number of lifeboats on board ships must be of the Class I type, while the remainder may be Class II boats, the object of this ruling being to provide boats which could readily be nested under the Class I boats and carried under davits. Accordingly, the design with partly collapsible sides was approved for this purpose, as it is peculiarly adaptable to nesting.

Just before the International Conference was called, the Lundin boat was put on the market. This boat has been fully described in these pages and is familiar to most seafaring men. Although the Lundin boat is of the semi-collapsible type, its performances in actual tests have been such that it is classified as a Class I boat. It is a decked lifeboat with fixed bulwarks above the deck and collapsible sides or weather boards on the bulwarks. Two Lundin boats can be stowed in the same space as one standard rigid boat, but although this was a great step forward there has recently been a growing demand for a lighter, less expensive type of boat, even more compact, to stow under standard or Lundin boats.

The Welin Marine Department of the American Balsa Company, Inc., New York, has developed a Class II boat which might be called a "Lundinized collapsible," for it has some of the most important advantages of the Lundin boats, together with the virtues peculiar to collapsibles, viz., it has the strength and dependability of a first-class

Fig. 2.—Broady Collapsible Lifeboat Launched with Five More Than Rated Number of Passengers on Board

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lifeboat and will stow in the small space occupied by a collapsible. This has been called the Broady boat.

The new type of boat is built of steel with an absolutely flat bottom and straight sides, the bottom being reinforced by a network of framing on which the footlings rest. The rigid sides are finished at the top with angle iron carried all around the boat and on this rest the thwarts, as well as a special wooden framework to which the collapsible sections of the sides are hinged. These folding weather-boards are in six parts and so arranged that one man can raise three at a time, and in two operations make the boat ready for occupancy. All sections are secured by self-locking braces. Great reserve buoyancy is secured by Balsa fenders on the outside and galvanized-steel-air tanks inside the boat. Extra heavy fittings are provided and so arranged that the loaded boat, when hanging from the tackles, is exceedingly stable, this being most unusual in boats of such shallow construction.

There was some doubt as to how the boat would stand the test of hanging free in the air when fully loaded, viz., it was feared that there would be undue deflection on account of its flat bottom. At the official tests, however, it was found that, with the boat swung clear and hanging from its own fittings loaded with five more persons than its actual rated capacity, the deflection was only ⅛-inch. In the water the boat was found very steady and gave ample protection to the occupants.

As the Broady type boat carries Balsa fenders, like the original Lundin boat, it is equally well protected against smashing from contact with the sides of the ship.

The 26-foot and 28-foot Broady boats when ready for nesting have a total height of only 2 feet 6 inches, which is exceedingly low, being about 6 inches lower than their prototype, the Lundin boat. All the experience gained in building Lundin and other lifeboats has been put to good use in the construction of this new development in space-saving and life-saving boats.

Ship Repair Facilities on the Gulf

BY CAPT. C. A. MC ALLISTER, U. S. C. G.*

THE rapid increase of our merchant marine has naturally created an insistent demand for repair and docking facilities. Nowhere has this demand been greater than in ports bordering on the Gulf of Mexico. New Orleans, the leading shipping port of the South, is rapidly increasing its foreign trade, and has had the foresight not alone of creating a magnificent dock system, but has vastly increased its ship repairing and dry docking facilities.

The photographs on page 361 well illustrate the progressive spirit in this busy port, as they show a ship built in New Orleans docked in one of the new floating dry docks constructed and operated by a New Orleans firm, The Jahncke Dry Dock & Ship Repair Company. The ship is the non-sinkable French steamship *Gauchy*, built by the Foundation Company for the French Government.

The dock is a new one of the Donnelly type, capable of lifting a 12,000-ton ship. This new dock can be operated in two sections, capable of lifting a 4,000-ton ship and an 8,000-ton ship, respectively. There is also being constructed an 8,000-ton dock of the Crandall type for operation by this firm. This will give three docks to be operated on a splendid section of the waterfront within the city limits, 1,500 feet in length.

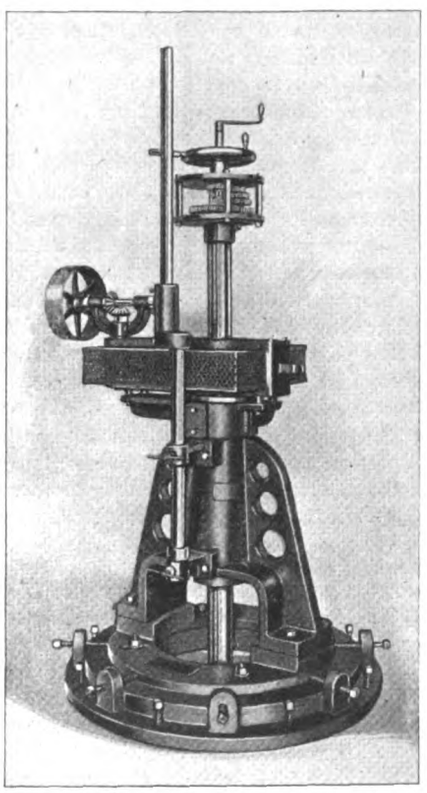
The Jahncke yard, to be operated solely for repair work, is splendidly equipped with a large machine shop, wood-working shop and all necessary facilities for prompt work. A spur from the railroad runs along the entire waterfront of the yard. It has a large power plant, with its own electric generators, air compressors, etc. The pumps for operating the docks are electrically driven, and are capable of lifting the largest vessels within thirty-five minutes.

Heretofore New Orleans has been compelled to utilize the navy yards floating dock for lifting large vessels. As it is estimated that the port of New Orleans, even with these docks, will have about 260 tons of vessels operating from that port for each 1-ton capacity of dry docks, it can readily be seen that this new repair enterprise will probably have to be run at capacity even under normal conditions.

*Vice-president, American Bureau of Shipping, New York.

Rudder Pintle and Deck Boring Machine

TO facilitate the boring of rudder pintles when in position on the vessel, the Pedrick Tool and Machine Company, Philadelphia, Pa., has recently developed the machine illustrated on this page. This obviates the use of a long, unhandy bar as well as the skill, patience and inconvenience attendant upon the setting-up of the bar. Primarily the device is made possible by a patented method of making a portable boring bar travel, thereby providing the means of driving and feeding other boring bars or tools.



Machine Developed for Boring Rudder Pintles in Place on Vessel

As will be observed from the illustration a V-shaped frame which supports the boring bar, feed and driving mechanisms is bolted to a circular plate. A self-contained machine is hereby provided that may be taken to any place where there is work for it to do. Its convenience of operation is further increased by the use of a large circular base plate to which the circular plate of the machine is attached. In the base plate, a number of radial set screws will be seen. These are used to shift

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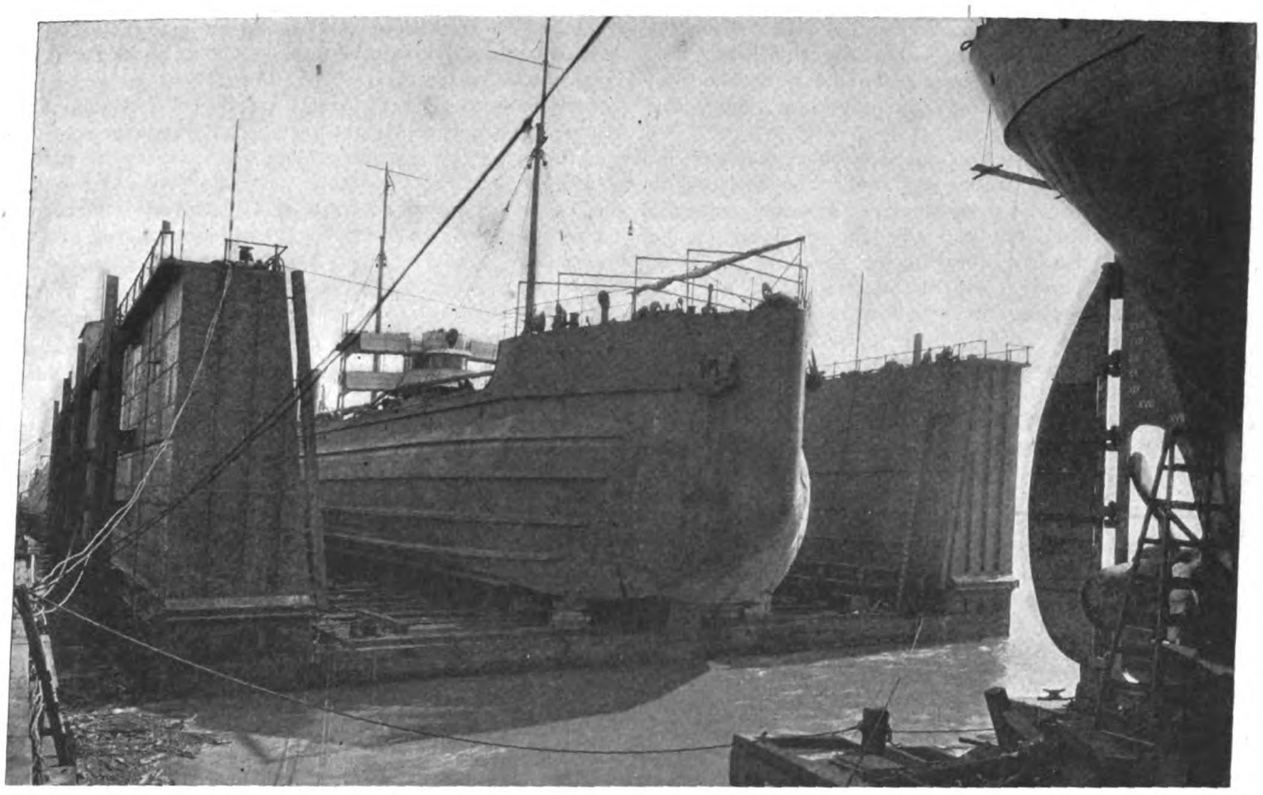

Fig. 1.—New Orleans-Built Ship in New Orleans-Built Dry Dock

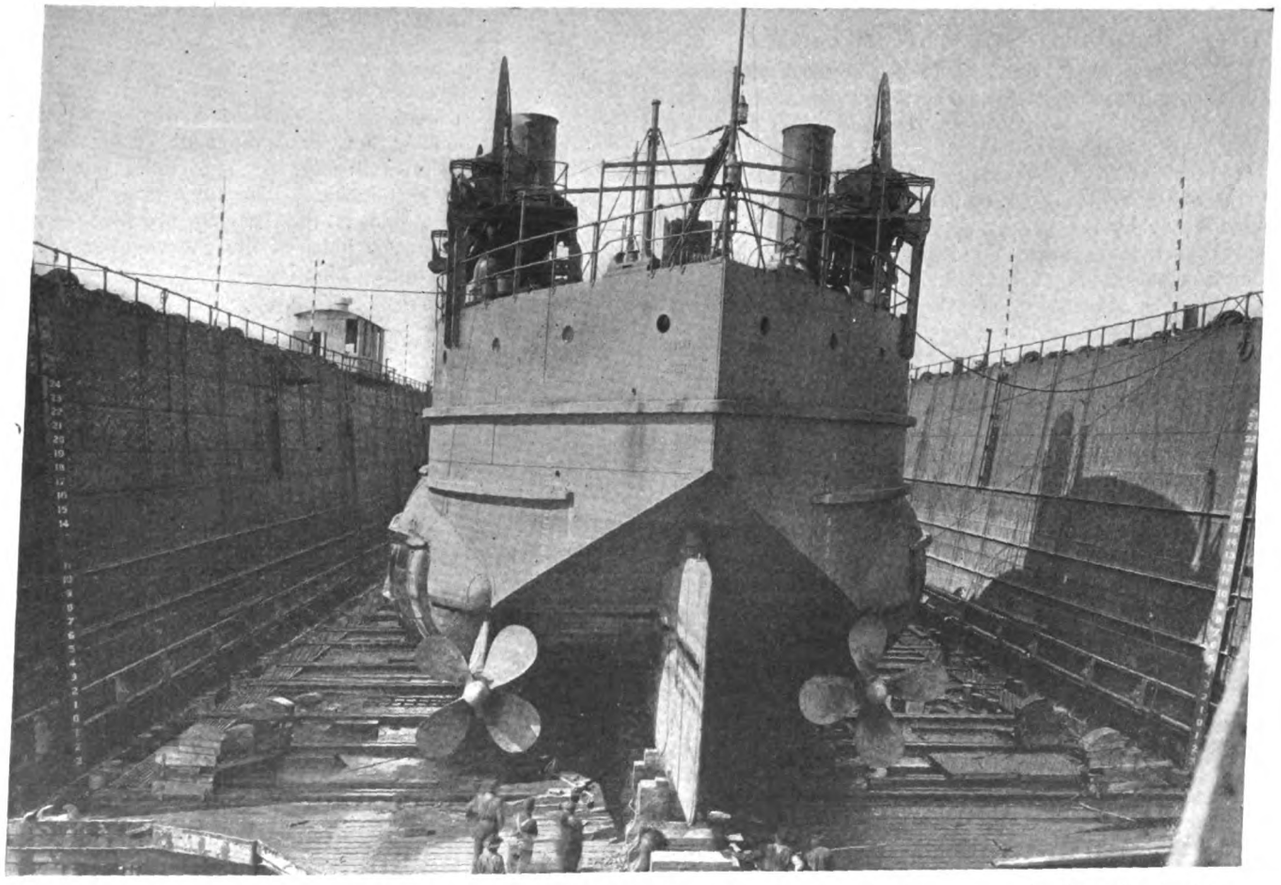

Fig. 2.—French Steamship *Gauchy*, of Non-Sinkable Type Built by Foundation Company, Docked in Donnelly Type Floating Dry Dock at Yard of Jahncke Dry Dock & Ship Repair Company, New Orleans, La.

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the machine to its exact location and hold it there after it has been set in approximately the correct position. This adjustment provides for 3 inches of movement out of center in any direction and is an important time-saving feature.

The boring bar in the machine is 4 inches diameter and 8 feet long, giving 48 inches of travel. The feed case on top of the bar provides three changes. It is reversible and is provided with a crank handle for obtaining quicker movement of the bar in raising or lowering it. When the handwheel revolves with the bar the feed is not operating, but by keeping the wheel from turning the feed becomes automatic. The upright shaft shown in the illustration is the means of holding the handwheel stationary and controlling it from a convenient position. The end of the bar is bored for a No. 6 Morse taper in which other sizes of bars can be inserted.

A very desirable way to equip the machine, it is claimed, is by having sectional auxiliary bars 4 inches diameter, 5 feet long with a No. 6 Morse taper on one end and the same size socket in the other. The sections as needed are put together and secured by taper pins.

If an opening in the deck is wanted, the machine can be placed in position and a hole started in the solid plates until drilled and bored large enough to permit a through bar to be attached. Cutters may be spaced on the auxiliary bars at proper intervals so that several holes may be bored at one time, as the driving gearing is of ample power for such work.

Arrangement for belt drive is shown in the illustration but air or electric motors may be connected whenever these methods are desired.

Standardizing Tackle Blocks*

FOR some time, naval architects, engineers and draftsmen, as well as the owners and operators of various types of ships, have recognized the fact that there has been a sad lack of data in regard to the tackle blocks used in their rigging equipments. This has been especially true of the malleable iron shell and steel shell blocks used for heavy loads.

It is true that tackle-block manufacturers have had certain standards of construction, and that it has been possible in some cases to secure from them dimensions of various parts and fittings. How these dimensions were arrived at, however, could not be determined, and it has been only through the wasteful process of repeated failure in actual service that tackle-block users have determined what sizes and types of blocks might be used for specific purposes.

Because of these conditions, the Emergency Fleet Corporation was placed at a great disadvantage during the war. Efforts were made to obtain adequate data from the block manufacturers, but because of their inability to secure the complete information required it was necessary for their draftsmen to do the best they could with the material available. The extreme wastefulness of this method has been amply proven in the breaking and binding of the specification blocks when the ships were loading, and in the heartbreaking delays, due to the necessity of securing blocks for replacement.

This state of affairs is known to all shipbuilders, and has often been deplored. To a lesser extent they, too, have had to learn by bitter experience, and the standards arrived at in their specifications are based almost entirely on observation and a knowledge of working conditions.

*Data supplied by the Engineering Department of the Parish Supply and Manufacturing Company, Chicago, Ill.

An effort has been made by block manufacturers to remedy this lack of information, and tackle block users may now secure scientifically determined data in regard to every detail and specification. Engineers have completed numerous experiments and tests, which have proved that in the design of a tackle block the stresses in various parts of the block, resulting from the load carried, may be determined with a considerable degree of accuracy. This information may be used in properly designing the various parts.

Typical Calculations for Tackle Block Design

As a typical example of the methods employed, a triple, heavy-pattern, diamond-shell block, Fig. 1 may be taken.

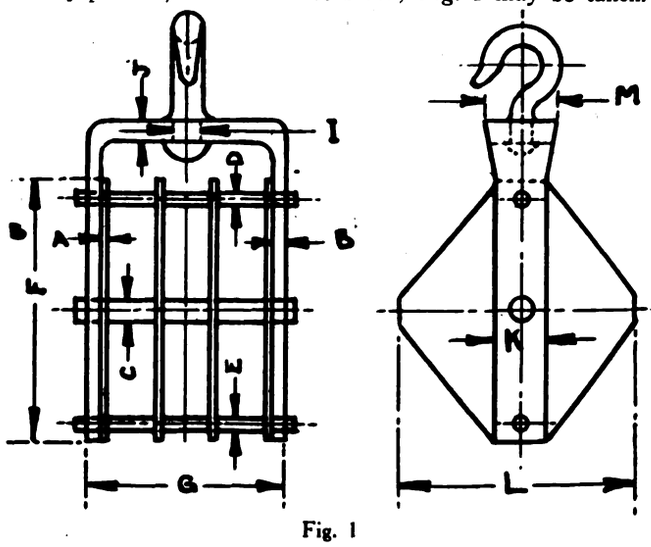

Fig. 1

This block has 12-inch sheaves designed to carry a load of 7 tons. The hook for the hoist is a number 13 Williams-Vulcan hook with a shank diameter of 1¾ inches.

The strap is shown in Fig. 2. The center pin has a diameter of $d = 1\frac{1}{2}$ inches. The important factor in the design of the pin is the bearing pressure of the bronze bushings in the hubs of the sheaves, per square inch of projected area. This is

$$p = \frac{Q}{Z' \times d} = \frac{14{,}000}{4\frac{7}{8} \times 1\frac{1}{2}} = 7{,}920 \text{ pounds per square inch,}$$

where: Q = total load on block,
Z' = combined length of hubs of sheaves,
d = diameter of pin.

The resultant pressure is comparatively low because the more or less intermittent use of a tackle block permits much higher pressures, especially in the case of a high-grade bronze block. The pin may then be checked for bending stresses, considering it as a beam supported at both ends and carrying a uniformly distributed load of 14,000 pounds. However, the pin receives considerable support from the cheek plates between the sheaves, which reduce the resultant stresses very considerably; the amount of this reduction it is, however, impossible to calculate with any degree of accuracy.

The sides of the strap are in tension, the weakest section being at the center pin. This section is shown in Fig. 3. The load is $Q/2$, so that we have the equation

$$\frac{Q}{2} = (a - d)\, b\, S_t,$$

in which S_t is the safe tensile stress of the material. A factor of safety of 4 or 5 may be used, which will give a

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value of 12,000 to 16,000 for mild steel. We can now assume a value for either a or b and calculate the other dimension. Taking b at 5/8 inch, and S_t at 12,000, the equation becomes;

$$\frac{14{,}000}{2} = (a - 1\tfrac{1}{2}) \times \tfrac{5}{8} \times 12{,}000.$$

Solving this for a, the result is $a = 2.44$ inches, which for reasons of construction is increased to 3 inches.

The crown of the strap is treated as a beam supported at the center and carrying a load, $Q/2$, at each end. The

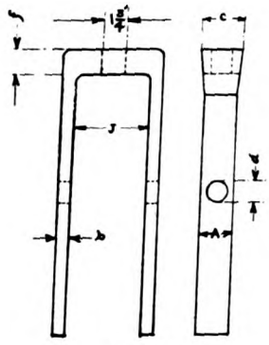


Fig. 2

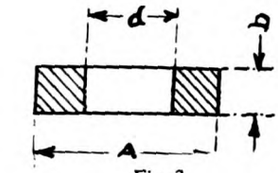


Fig. 3

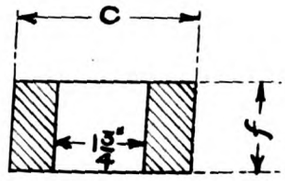


Fig. 4

dangerous section, Fig. 4, is at the center. The bending moment at this section is;

$$M = \frac{Q\,Z}{4}.$$

We therefore have the equation;

$$\frac{Q\,Z}{4} = S_b\,Z,$$

in which S_b is the safe bending stress and Z is the section modulus, which for this section is $1/6\ (c - 1\tfrac{3}{4})\ f^2$ The equation thus becomes

$$\frac{Q\,Z}{4} = 1/6\ (c - 1\tfrac{3}{4})\quad S_b.$$

A value of c is now assumed, say 4 inches, and S_b is taken at 16,000. Solving the equation for f the result is

$$\frac{14{,}000 \times 7}{4} = 1/6\ (4 - 1\tfrac{3}{4})\ f^2 \times 16{,}000.$$

$$\text{and } f = \sqrt{\frac{6 \times 14{,}000 \times 7}{4\,(4 - 1\tfrac{3}{4}) \times 16{,}000}} = 2 \text{ inches.}$$

Determining the Stresses in Wire Rope

It may be well to calculate the stress in the wire rope which is 3/4-inch diameter, the usual 6 strand, 19 wire per strand hoisting rope. A very important factor, frequently neglected, is the stress produced in wire rope due to its being bent over a sheave of comparatively small diameter. This stress must be added to the tensile stress produced by the load carried.

According to Bach the stress due to bending a wire rope over a sheave is

$$S_b = 3/8\ E\ \frac{h}{D},$$

in which E is the modulus of elasticity (30,000,000 for steel), h is the diameter of the individual wires of the rope, and D is the sheave diameter. For a pair of triple blocks, each rope will carry 1/6 of the total load of 2,400 pounds. The diameter of the wire is approximately 1/15 of the rope diameter, or 0.05 inch. Then

$$S_b = 3/8 \times 30{,}000{,}000 \times \frac{.05}{12} = 47{,}000 \text{ pounds per square inch.}$$

The stress due to the load S_t is

$$S_t = \frac{Q}{n\,A},$$

where A is the sectional area of each wire, and n is the number of wires in the rope, so that

$$S_t = \frac{2{,}400}{119 \times 0.00196} = 10{,}300 \text{ pounds per square inch.}$$

The total stress is

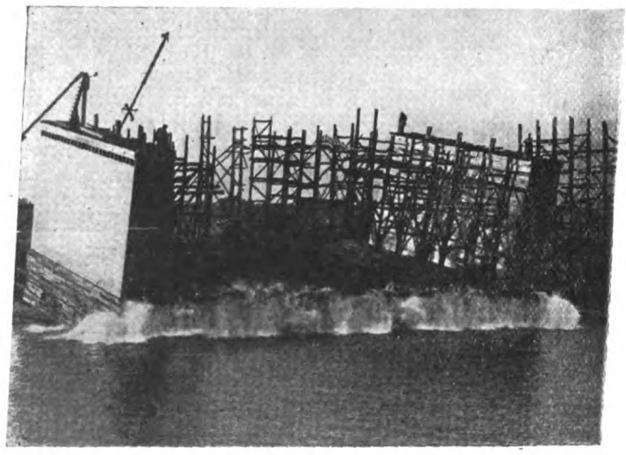
$$S = S_b + S_t = 57{,}300 \text{ pounds per square inch.}$$

It is thus seen that the bending stress in this case is by far the most important. For high-grade plow steel rope the factor of safety is about 3, which is not too low for such material.

Each size block may be treated in the same manner and calculations carried through, by the use of the same formulas. Such data in handbook form have been compiled by the Parish Supply and Manufacturing Company, for the use of naval architects, engineers, rigging draftsmen and others who are interested in the application of scientific methods to the production of tackle blocks. Such books will be supplied by this company on request.

New Crandall Floating Dry Dock

The third pontoon of the floating dock being built for the Bruce Dry Dock Company, Pensacola, Florida, was successfully launched on February 7. Indicators on the pontoon showed no measurable deflection during the launching. It is believed that the construction of this pontoon establishes a world's record, it being built and launched in 39 days and 6 hours from the time of laying the first timber. The floating dock is being constructed by the Aberthaw Construction Company under the supervision of Paul H. MacNeil, resident engineer of The Crandall Engineering Company, drydock engineers, East Boston, Mass.



Launching of Pontoon for Floating Dry Dock at Pensacola

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Developments in High Vacuum Apparatus*

BY G. L. E. KOTHNY

Steam turbines require the highest possible vacuum for highest efficiency and economy. The importance of this has been realized, and considerable research work has been carried out and many developments have been made in relation to the condensation of steam and the extraction of air. It is intended in the following to record some developments which have been made during the last few years in the extraction of air from marine condensers.

THE recognized limits of vacuum for well-designed marine turbine surface condensers based upon the inlet temperature of the circulating water are as follows:

1½ inches Hg. absolute with sea water at 60 degrees F.
2 inches Hg. absolute with sea water at 70 degrees F.
2.4 inches Hg. absolute with sea water at 80 degrees F.
2.75 inches Hg. absolute with sea water at 85 degrees F.

When estimating the correct size of air pump to use, the chief factor to bear in mind is the normal air leakage which the pump must handle. No definite rule can be laid down for the amount of air leakage, as it depends on the size and character of the installation. In small installations this is relatively higher than in large ones.

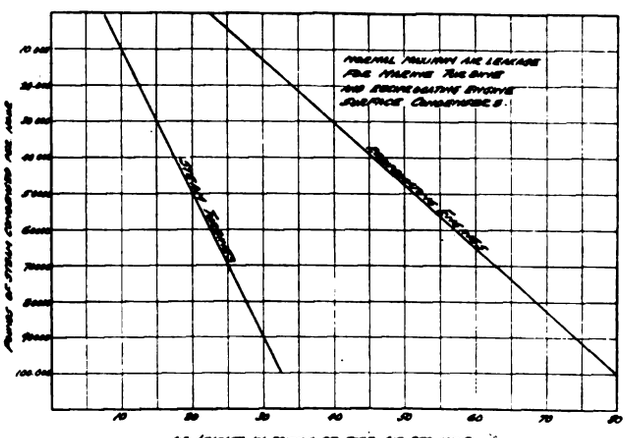

Fig. 1.—Normal Air Leakage for Marine Condensers

Also in condenser installations where a large number of auxiliaries, particularly those located on deck, are exhausted into the main condenser, the air leakage is greater than in a normal installation, and a larger air pump will be required.

Extensive investigations have shown that the normal air leakage for marine surface condenser installations can be limited to the amount shown in Fig. 1, provided that any auxiliaries exhausting into the main condenser do so at a pressure slightly above atmosphere. The curve illustrated in Fig. 1 is based on the total amount of steam which the condenser receives. It also includes the air contained in the exhaust steam. The air received from the condenser is always fully saturated with vapor, the amount of which depends upon the temperature and absolute pressure. The relations between water vapor and air at different absolute pressures and temperatures based on Dalton's Law are illustrated in Fig. 2. In determining the air-handling capacity of the pump, the amount of vapor should be deducted from these curves and added to the normal air leakage given in Fig. 1.

In looking over Fig. 2 it will be seen that at a constant absolute pressure the amount of vapor decreases with the drop in temperature. It is therefore desirable to remove the mixture at the lowest possible temperature in order to decrease the size of air pump. This fact has been recognized, and has led to the adoption of the dry system in which the air and the condensate are removed separately.

The dry system permits the removal of the air and vapors at the lowest possible temperature by a dry air pump; the condensate is taken away at a higher temperature by either a turbine-driven or reciprocating condensate pump. Since the adoption of the dry system, many developments have been made in dry air pumps, the most notable being the steam air ejector, which, due to its many

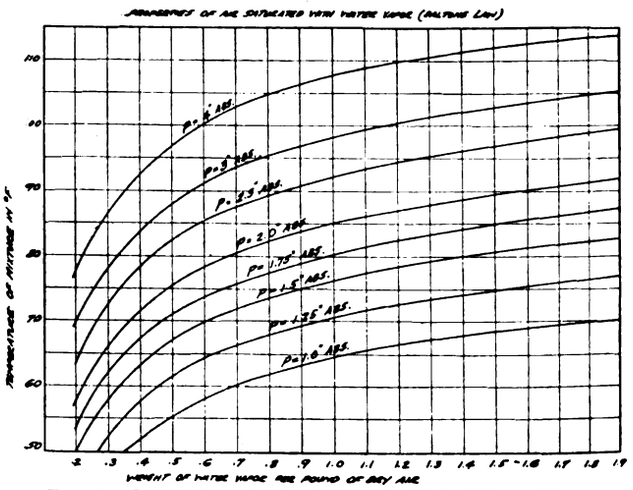

Fig. 2.—Properties of Air Saturated With Water Vapor

advantages, has been extensively used during the last three years.

The use of steam jets for the removal of air has been known for over fifty years. As early as 1868 a patent was granted for a steam-jet air pump. But this type of pump has never been developed to produce high vacua commercially until recently. This was due to the lack of the correct knowledge of the properties of steam and the want of interest in high vacuum. During the years 1900 to 1910 the properties of steam have been more accurately determined by several prominent scientists who made it possible to carry out experiments for the improvement of steam air ejectors. At the same time the demand for high vacuum became more pronounced, due to the adoption of the steam turbine.

The steam air ejector is a compressor in which the air to be compressed is entrained by one or more steam jets, which move through the entrainment space at a very high velocity. The entrainment is made by friction. The kinetic energy, originating from the steam jets, and contained in the mixture of air and steam after entrainment, is transformed into pressure in a channel called the diffuser.

Referring to Fig. 3, air enters through opening *A* into the entrainment chamber *E;* live steam expands through

*From a paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1919.

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one or more nozzles whereby its static energy, due to its pressure, is transformed into kinetic energy. This transformation causes the steam to leave the nozzle with a velocity ranging from 3,000 to 4,000 feet per second. The steam jets *J*, while passing through the entrainment chamber *E*, entrain the air and give up part of their kinetic energy to the same. The outlets of the nozzle or nozzles are arranged opposite the opening of the diffuser, and the mixture of steam and air enters the diffuser at a somewhat lower velocity than that of the steam jets leaving the nozzles. The mixture is gradually brought practically to a rest in the diffuser *D*, thus increasing its static pressure to or slightly above atmosphere.

The efficiency of a steam air ejector depends upon the magnitudes of three losses:

(a) The friction losses in the expansion nozzle.
(b) The impact losses during entrainment.
(c) The losses in the diffuser.

Due to the development of steam turbines the nozzle design has approached nearly the highest degree of efficiency possible, and the friction losses in a well-designed steam nozzle are seldom more than 10 percent (see H. Frederic and Kemble, Transactions of the American Society of Mechanical Engineers, 1909). These losses depend mostly on the length of the nozzle and the condition of the inner surface.

The loss due to impact is influenced by the relation that the momentum of the steam, plus the momentum of the air before the impact, must equal the momentum of the co-mingled steam and air after impact. If we designate the amount of live steam to be G_1 pounds, the amount of air entrained G_2 pounds, the velocity of the live steam at the outlet of the nozzles V_1, the velocity of the air V_2, and the velocity of the mixture V_3, we can write the following equation:

$$G_1 \times V_1 + G_2 \times V_2 = V_3 \times (G_1 + G_2).$$

The impact loss can be minimized by letting the air acquire a higher velocity before combining with the steam jets. This, however, would make it necessary to produce a smaller absolute pressure in the entrainment space and to provide an annular air nozzle ahead of the same. As a result the pressure rise in the diffuser would have to be greater than otherwise, and consequently the loss in the diffuser will be increased. Careful experiments and calculations have shown a certain range of conditions within which the sum of all the losses is a minimum. The underexpansion and arrangement of an air nozzle prior to the entrainment has been found to be of advantage only for very small compression ratios, which, however, are not used in steam air ejectors producing high vacuum.

The losses in the diffuser are considerably larger than those in the nozzle. They range from 25 to 50 percent and are influenced by the length and the shape of the diffuser, as well as by the conditions of the inner surface.

The ratio of compression is the ratio between the absolute pressure of the air at the air intake and that at the air discharge. Since turbine condensers require vacua of 2-inch Hg. absolute or less, the ratio of compression has to be 1 to 15 or more. While it is possible to obtain such a high compression ratio in a single stage, carefully made experiments have shown the inadvisability of using such a high compression ratio single-stage ejector for practical purposes. The following conclusion will illustrate why:

Assumed that a single-stage air ejector is designed to produce a vacuum of 2-inch Hg. absolute. When starting this ejector, the absolute pressure at the air intake is the same as that at the air discharge, namely, atmospheric pressure. The steam will leave the nozzle with considerably less velocity than that which it would obtain under normal operation. The efficiency of the nozzle will be decreased, and the entrainment surface (outer surface of the steam jet) will be decreased. The air to be entrained is in a less rarefied state, hence the loss due to the impact during entrainment is also greater. Consequently the velocity of the mixture is smaller and its volume is larger. As this mixture has to pass through the throat of the diffuser, the sectional area of the diffuser would have to be enlarged for starting conditions. If this is not done, starting will become impossible. Assumed that the steam jet after leaving the nozzle does not touch the diffuser walls, but leaves an annular opening or channel between the outer surface of the steam jet and the inner walls of the diffuser through which the air is entrained (as shown in Fig. 4), a vacuum will be produced which will gradually increase with the decrease of the losses. The velocity of the steam will increase with the

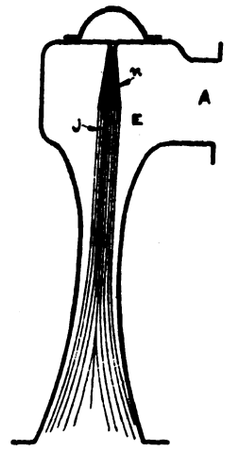

Fig. 3

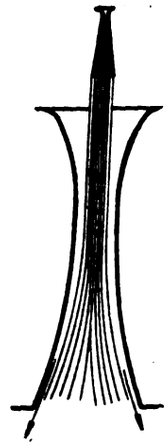
Fig. 4

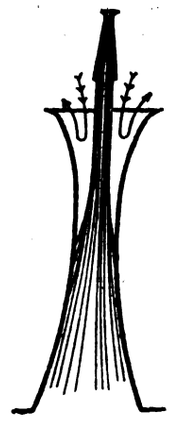
Fig. 5

vacuum. This in turn will retard the enlargement of the diameter of the steam jet. The increasing difference of pressure in the diffuser will recede farther towards the diffuser throat. And if the designed vacuum is obtained before the steam jet touches the diffuser wall, the ejector will start spontaneously.

If, however, the jet touches the diffuser walls before the designed vacuum is obtained, the entrained air cannot pass. It will re-circulate, as illustrated by the arrows in Fig. 5, and the ejector will never start. This will happen if a single-stage ejector is designed for 2-inch Hg., because its diffuser throat area will be entirely too small for starting conditions. If increased in sectional area to overcome those, the section will be too large to be filled out with the co-mingled steam and air at 2-inch absolute, and atmospheric air will rush back into the entrainment space and the desired vacuum will not be obtained.

To overcome this difficulty such a single-stage high-compression ratio ejector would have to be provided with either a flexible diffuser or special arrangements for starting.

In all ejector designs, whether for low or high compression ratio, the above facts have to be given careful consideration. The diffuser throat is generally enlarged over the required size for design conditions. This enlargement represents a compromise between diffuser losses and the self-starting capacity. The latter is more important than high efficiency. In practical installations vacuum conditions vary, and lack of this self-starting characteristic will cause the ejector to stop working, which may have serious consequences. Experiments have shown

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that the maximum ratio of compression for a single-stage ejector working in connection with condensers should not exceed 1 to 7. In other words, when it is desired to have more than 25½-inch vacuum with 30-inch barometer, it is advisable to arrange two ejectors working in series and divide the ratio of compression. All high-vacuum ejectors used with marine turbine condensers consist of two stages—the first stage, which is connected to the air suction of the condenser and which exhausts into the second stage at a pressure varying from 4 to 10-inch Hg. absolute; the second stage, which compresses the mixture of steam, air and vapor received from the first stage to a pressure slightly above atmosphere. The steam used in both stages, while passing through the ejector, gives up its energy but does not lose its heat, with the exception of some small losses due to radiation. The exhaust from the ejector is discharged into the feed tank. The heat in the steam is by this means transmitted directly to the boiler feed with practically no loss.

The characteristic of the performance of the steam-air ejector is illustrated in Fig. 6. Curve *A* shows the air-

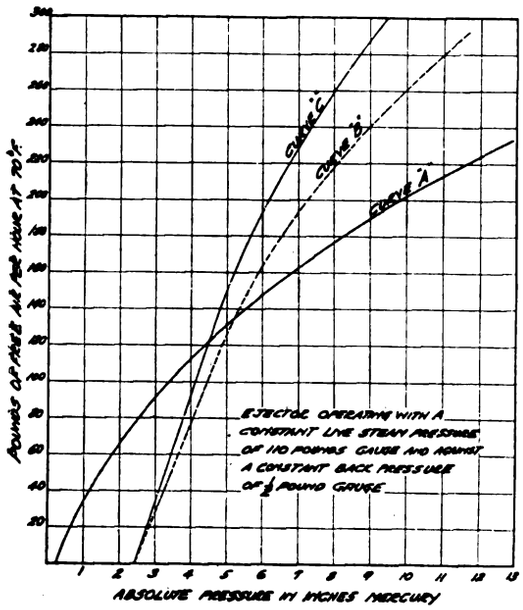
CURVE "C"
CURVE "B"
CURVE "A"
EJECTOR OPERATING WITH A CONSTANT LIVE STEAM PRESSURE OF 110 POUNDS GAUGE AND AGAINST A CONSTANT BACK PRESSURE OF ½ POUND GAUGE
ABSOLUTE PRESSURE IN INCHES MERCURY

Fig. 6.—Characteristics of Performance of Steam-Air Ejector

handling capacity of a two-stage ejector designed for 2 inches absolute at different absolute pressure when exhausting dry air and when being supplied with a constant quantity of dry saturated steam of constant pressure, and when exhausting against a constant back pressure of ½-pound gage. It will be noted that the air ejector is capable of producing an absolute pressure of 0.25-inch Hg. at dead end (with the air suction blanked off). The capacity increases steadily with the increase of absolute pressure.

The actual dry-air handling capacity of the second stage of the same ejector working under similar conditions is illustrated in curve *B*. The steam consumption of the second stage is, of course, less than the total steam consumption of the two stages.

Curve *C*, shown in dot-and-dash lines, represents the air-handling capacity of the second stage based on the total steam consumption of the two-stage ejector.

Comparing these curves it will be noted that at 5 inches Hg. absolute the second stage alone handles as much air as both stages together, and that from this point the capacity of the second stage increases over that shown in curve *A*. This is due to the fact that, when both stages

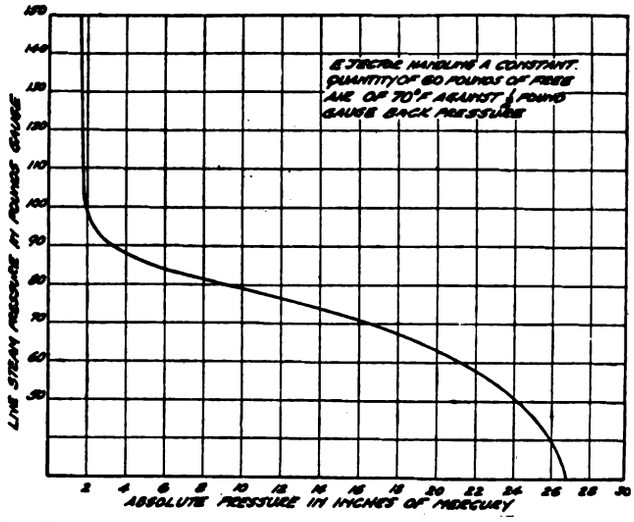
EJECTOR HANDLING A CONSTANT QUANTITY OF 60 POUNDS OF FREE AIR PER HOUR AT 70°F AGAINST A CONSTANT BACK PRESSURE
LIVE STEAM PRESSURE IN POUNDS GAUGE
ABSOLUTE PRESSURE IN INCHES OF MERCURY

Fig. 7.—Curve Illustrating Effect of Variations in Live Steam Pressure

are working, the second stage also compresses the steam discharged from the first stage. One is accordingly led to the conclusion that it is advisable to shut off the steam supply to the first stage at about 5-inch Hg. absolute to save the live steam used in the same. Curve *C* also indicates that at about 4.5-inch Hg. absolute or more a single-stage air ejector should be used, provided it can be designed self-starting.

In connection with Fig. 6 it must not be assumed that the curves indicated are in every sense absolute. They depend entirely upon the ratio between the compression ratios of the first stage and those of the second stage. The curves shown are those of an ejector which has been extensively used in marine installations.

The main factors (excluding those referring to the design) controlling the performance of a steam-air ejector are:

(a) The quality of the live steam supplied.
(b) The pressure of the live steam supplied.
(c) The back pressure at the discharge.
(d) The condition of air handled.

The live steam supplied to the steam-air ejector should be dry saturated or slightly superheated. If less than 98 percent saturated, the losses will rapidly increase and the stability of operation will suffer. The presence of water in the steam can easily be detected by a whistling noise and a sudden drop of pressure of the steam at the pressure

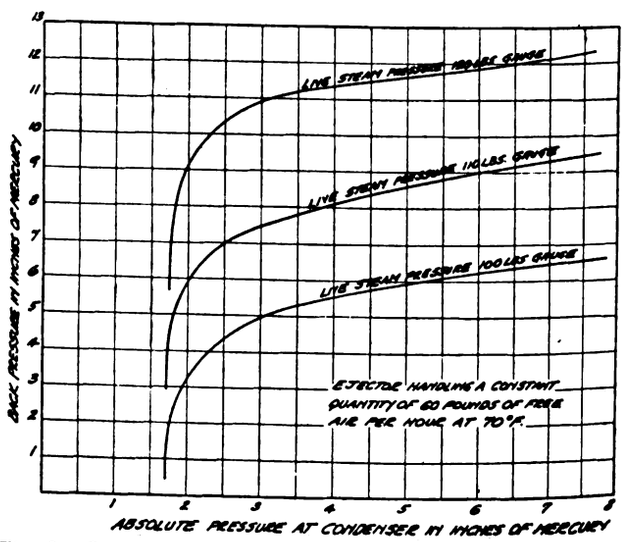
LIVE STEAM PRESSURE 110 LBS GAUGE
LIVE STEAM PRESSURE 100 LBS GAUGE
EJECTOR HANDLING A CONSTANT QUANTITY OF 60 POUNDS OF FREE AIR PER HOUR AT 70°F
BACK PRESSURE IN INCHES OF MERCURY
ABSOLUTE PRESSURE AT CONDENSER IN INCHES OF MERCURY

Fig. 8.—Curves Illustrating Effect of Variations in Back Pressure

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gage arranged ahead of the inlet to the nozzle. If the possibility of obtaining wet steam exists, a steam separator should be provided.

High superheated steam, while good for steam turbines, does not offer any advantages for the steam-air ejector. Its compression in the diffuser becomes difficult, and this counterbalances the benefit obtained from its use in the nozzles.

The necessary minimum pressure of the live steam at the inlet to the nozzles is a function of the compression ratio the ejector has to produce. The kinetic energy of the steam, after expansion through the nozzle, has to be large enough to compress the mixture of steam and air. The minimum steam pressure employed varies from 100 to 110 pounds gage. The influence of the variation in steam pressure on a two-stage air ejector designed for 110 pounds gage removing a constant quantity of air against a constant back pressure is shown in Fig. 7. It will be noted that even low-steam pressures will produce some results.

The effect of the back pressure upon the performance is illustrated in Fig. 8, several curves for different live-steam pressures being shown. All are based upon a constant air-handling capacity. These curves also evidence the possibility of overcoming a higher back pressure by an increase in the live-steam pressure.

The effect of the conditions of the air entrained is based upon the following considerations. Air saturated with water vapors weighs considerably more than dry air. Since we can assume that the ejector will handle the same total weight whether the air is dry or saturated, the application of the Dalton Law (see Fig. 2) will enable the determination of the respective quantities. Referring to curve *A* in Fig. 6, at 2-inch Hg. absolute, 77 pounds of dry air were handled when drawn directly from the atmosphere. Assume now that fully saturated air is to be handled at the same absolute pressure and that this air has a temperature of 80 degrees F. The curves of Fig. 2 indicate the presence of 0.67 pound of water vapor to each pound of dry air in 1.66 pounds mixture. Hence the ejector would theoretically handle $\frac{77}{1.67} = 46$ pounds of dry air. Careful experiments have shown the amounts actually handled to be less than the calculated theoretical values. This is partly due to small globules of water suspended in the saturated air being carried into the ejector. An air ejector handling a mixture containing a considerable amount of vapor also has greater impact losses during entrainment and greater losses in the diffuser. The weight of mixture handled by the ejector becomes less as the proportion of vapor to dry air increases. Since the air withdrawn from a condenser is always saturated with water vapor, the above-mentioned condition should receive careful consideration when selecting the proper size of an air ejector for a condenser installation.

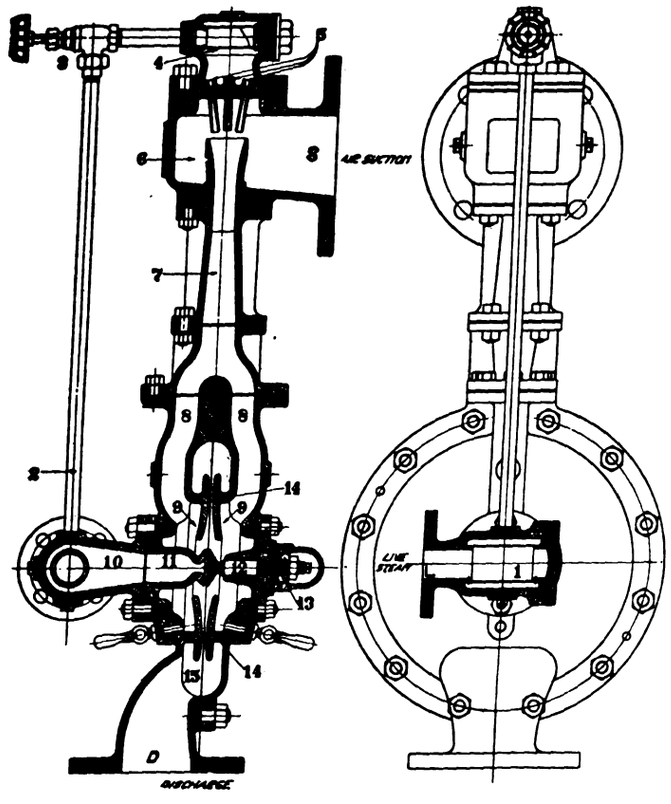

Fig. 9.—Cross Section Through Radojet Air Ejector

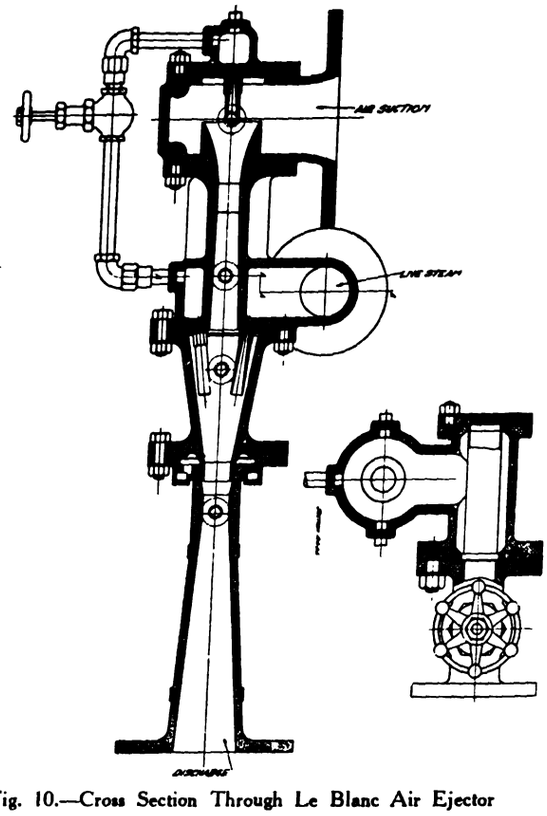

Fig. 10.—Cross Section Through Le Blanc Air Ejector

Having thus briefly indicated the principles of operation, as well as the most important factors in steam-air ejector design, several types of ejectors will be described which have been in successful operation in marine condenser installations over two years and thereby have proven their fitness for marine service. Only two types in a variety of sizes have so far been used in a large fleet of merchant marine and navy vessels.

These are known as the "Radojet" and the Le Blanc air ejector. Both are of the two-stage type, the stages being connected in series. A cross-section through the Radojet is shown in Fig. 9. Live steam is delivered from a source not shown through opening *L* through strainer screen 1, pipe 2, auxiliary steam valve 3, strainer screen 4, expansion nozzles 5, across suction chamber 6, of the

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first-stage ejector, which is in communication with the condenser through the suction opening *S*.

The steam expands in the nozzles, leaving the same with a very high velocity and, while passing across suction chamber 6, entrains the air and vapors to be compressed.

The mixture passes into the diffuser 7, from where it is discharged at higher absolute pressure than that of the air entering at *S* into a double passage 8 communicating with the suction chamber 9 of the second stage. These two suction chambers 9 are annular, giving the co-mingled fluid a large entrainment surface.

Steam is simultaneously delivered through the strainer screen 1 into passage 10, which communicates with the annular expansion nozzle formed between nozzle 11 and nozzle point 12. Nozzle point 12 may be adjusted toward or away from disk 11 by the adjusting screw 13, which forms part of it, to vary the cross-section of the nozzle passage, thereby changing the expansion ratio of the steam.

The steam delivered by the annular nozzle 11 expands between the same and nozzle point 12, leaving it as a jet of high velocity in the form of an annular sheet. In passing across the section chambers 9, it entrains the co-mingled air and steam received from the first stage and carries the mixture into the annular diffuser 14, thereby compressing it to slightly above atmospheric pressure and discharging it into casing 15, which has the discharge opening *D*.

The steam nozzles of the first stage are bronze, that of the second stage is of monel metal, and the nozzle point of special steel. The diffusers are bronze. In the smaller sizes, the diffusers form part of the casing, while in the larger sizes the diffusers are secured to a cast-iron casing by bolts, forming a metal ground joint with the casing.

The strainers ahead of the nozzles protect them from becoming clogged by foreign substance. They are easily removed and are made of perforated monel metal or monel metal wire gauze. The openings in the strainers are smaller than the throat of the nozzles.

The particular features of this type of air ejector are:

1. The use of a radial jet (from which the Radojet has derived its name), which has a greater penetrating force and larger entrainment surface than that of a cylindrical jet of equal length. Consequently better efficiencies are obtained.

2. The possibility of adjusting the expansion ratio of the live steam from the outside without changing the steam consumption. Referring to Fig. 9, it will be seen that the throat is located in nozzle 11, and that any movement of the disk to or fro will not change the cross-sectional area of the throat and therefore not affect the steam consumption.

A cross-section through the "Le Blanc" air ejector is shown in Fig. 10. It has one DeLaval nozzle in the first stage, and multiple DeLaval nozzles are arranged close to the inside of the diffuser walls in the second stage. It is claimed that the losses due to the impact in the second stage are reduced, since the mixture discharged from the first stage enters the entrainment chamber of the second stage with greater velocity and in a direction nearly parallel to the steam jets of the second stage. The throat of the diffuser in the second stage also has an opening 2 connected with the atmosphere. The object of this opening is to permit the air thus drawn in to form a flexible diffuser wall. At starting and at low vacua the pressure at the diffuser throat will be atmospheric. With the increase of vacuum this pressure will be lowered and the inrushing air will partly fill up the diffuser throat, thereby decreasing the effective area. While this arrangement conforms with the principle of self-starting as outlined above, it adds to the work of the second stage, as the air thus admitted has to be compressed and ejected.

There are also a number of other steam-air ejectors on the market, none of which to the writer's knowledge have been in operation for marine service. All of these have an inter-condenser between the first and second stage. The object of this inter-condenser is to reduce the work of the second stage by condensing the steam discharged from the first stage, thereby decreasing the total steam consumption 30 to 40 percent. While this scheme may look very attractive at first, a closer investigation will show that there is no advantage in using an inter-condenser between stages in marine installations.

On board a ship it is necessary to install a surface inter-condenser. The heat contained in the steam of the first stage is entirely lost, as it is absorbed by the circulating water. Provision has to be made for removing the

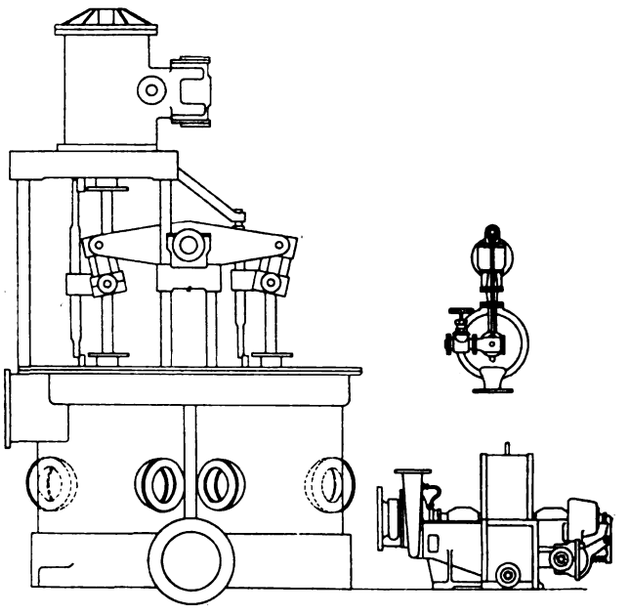

Fig. 11.—Comparative Outlines of Twin Beam Air Pump and Air Ejector

condensate from the inter-condenser. Circulating water has to be supplied to the inter-condenser, which means additional work. The weight of the inter-condenser air ejector with its necessary piping is about eight times that of the straight two-stage ejector. The space required is five times as large and the arrangement of the piping is complicated The increased weight and the larger space required mean a slight increase in propelling power. Space and weight also make it difficult to provide two or three steam-air ejectors with inter-condensers working in parallel. Such an arrangement can easily be made with a steam-air ejector without an inter-condenser, and has the advantage of increasing the flexibility and economy during light loads.

The gain in steam consumption by using the inter-condenser is more than counterbalanced by all the disadvantages mentioned. The arrangement with an inter-condenser also lacks the simplicity which a two-stage air ejector installation without inter-condenser possesses. According to the opinion of numerous marine operating engineers, simplicity is of greater practical value than the saving of a few pounds of live steam.

Until the appearance on the market of the steam-air ejector the twin-beam air pump quite monopolized the field. Therefore it will be interesting to compare the two types. Considering first the comparative steam consumptions based on equal air and condensate handling capacity

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it will be found that the steam consumption of the air ejector, plus that of a turbine-driven condensate pump, is lower than that of the twin-beam air pump, even if the latter is arranged with a dry and a wet cylinder.

The weight and space requirements are also decisively in favor of the air ejector outfit. Fig. 11 illustrates a set of either type of equal air and condensate handling capacity, and Table 1 gives the relative weight, cubical space and floor space.

TABLE 1

	Weight Lbs.	*Cubical Space Cu. Ft.*	*Floor Space Sq. Ft.*
Twin-beam air pump....	14,500	375	33
Two air ejectors and one condensate pump.....	2,100	18	8

Other comparative advantages of the air ejector are:

It has no moving parts nor valves, does not require lubrication, nor attendance during operation.

Its operation is noiseless, simple and reliable.

No foundations are required and no restriction as to location exists. It is to all intents and purposes a piece of pipe.

Since there are no moving parts there is no wear, and consequently the maintenance costs are practically nil.

When using a steam-air ejector the feed water carries less absorbed air into the boilers than when using a twin-beam pump. The condensate pump forms a self-contained unit. All the attention it requires is to see that its ring-oiling bearings are kept filled with oil. The discharge head of the condensate pump is not limited, as is the case with the twin-beam air pump. Since it operates independently from the air ejector the pump has greater flexbility and can easily take care of large amounts of condensate without influencing the air-handling capacity. This is not possible with the twin-beam air pump, in which the air-handling capacity is limited by the piston speed and simultaneously by the amount of condensate removed.

When using air ejectors and condensate pumps a considerable saving in weight and cost of piping can be made because the pipe sizes are smaller, as much higher velocities are permissible when dealing with water and air separately.

Steam-air ejectors are generally supplied in pairs for marine condenser installations, this subdivision having the advantage of reducing the steam consumption by operating with one under light loads or when the installation is air tight, also of providing additional capacity in case of unexpected leakage. In larger installations sometimes three or even four air ejectors working in parallel are being used with two condensate pumps.

This subdivision also gives an absolute assurance against a total shut-down, which may easily occur when using a single reciprocating type air pump.

As the condensate pump forms an essential part of an air-ejector installation a short description of several types of condensate pumps will be given.

A centrifugal type of condensate pump, driven directly by a steam turbine, has been extensively used. It has a single-inlet impeller mounted on the overhung end of the turbine shaft. The pump casing is bolted directly to the turbine casing, thus forming a rugged unit with only two bearings. This construction makes it impossible to throw the shaft out of alinement when bolting the pump down to the foundation or when connecting the piping. A vent is provided ahead of the inlet of the impeller and connected to the condenser to permit any air which may have been drawn into the pump through whirling of the condensate as it enters the suction pipe to return to the condenser and prevent the pump from becoming air-bound. The turbine is running at a constant speed, which is regulated by a speed governor; it also has an emergency trip. Carbon packings are generally used on the turbine glands. The pump has to remove the condensate under a high vacuum, and therefore has to overcome a suction head of 30 feet or more. This makes it necessary for the condensate to flow by gravity to the pump impeller, and it is advisable that the pump be submerged not less than 2 feet below the lowest water level of the condenser. This turbine-driven pump is supplied by the C. H. Wheeler Manufacturing Company, of Philadelphia.

Direct-acting reciprocating piston pumps, either vertical or horizontal, are also used for the removal of the condensate. Their design is adapted to the features peculiar to condensate pump service. Their submergency is more than that for the centrifugal type and is never less than 4 feet from the top of the discharge valves to the water level of the hot well. The stuffing boxes are water-sealed, and their piston speed does not exceed 25 to 30 feet per minute when handling double the normal capacity. The speed of the pump is controlled by a float arranged in the hot well of the condenser so as to prevent racing of the pump at light loads.

The arrangement of an air-ejector installation with turbine-driven condensate pump is illustrated in Fig. 12. Live steam at boiler pressure is delivered through the steam strainer to the pressure regulator; passing through the pressure regulator the steam is delivered to the main steam valve of the air ejectors at practically a constant pressure for which these have been designed to operate, the pressure regulator taking care of variation in the boiler pressure. The suction of the condenser is connected to the air suction of the ejectors by a tee, a gate valve being arranged so to permit the shut-off of each ejector. The discharge of the ejectors leads into the feed and filter tank.

A swing check valve is arranged close to the tank to prevent any water from rushing back into the air ejector if shut down before breaking the vacuum in the condenser.

Inside the feed and filter tank the mixture of steam and air is discharged through a submerged pipe perforated at the bottom. By coming into contact with the water the steam is condensed, while the air, forced to rise by the upward flow of the water, is liberated, escaping through a vent arranged in the top of the tank. Water is continuously supplied to the feed and filter tank by the turbine-driven centrifugal condensate pump, which delivers the condensate into the filter tank through a swing check valve, gate valve and a perforated pipe with holes diametrically opposite to that of the ejector discharge pipe. A vent pipe is arranged between the suction inlet of the condensate pump and the condenser.

A re-circulating pipe, with a strainer, a thermostatically operated valve and a globe valve, is provided between the feed and filter tank and the condenser to insure at all times a sufficient water supply for condensing the steam from the air ejectors.

During maneuvering or while at sea, the main engine or turbine supplying the condenser with exhaust steam may stop, consequently very little condensate will be delivered by the condensate pump to the feed and filter tank, and not sufficient to condense the discharge from the air ejector which at the time is in continuous operation.

To prevent a rise in temperature of the water in the feed tank over that desirable (usually 140 degrees F., depending, however, on the general arrangement of each

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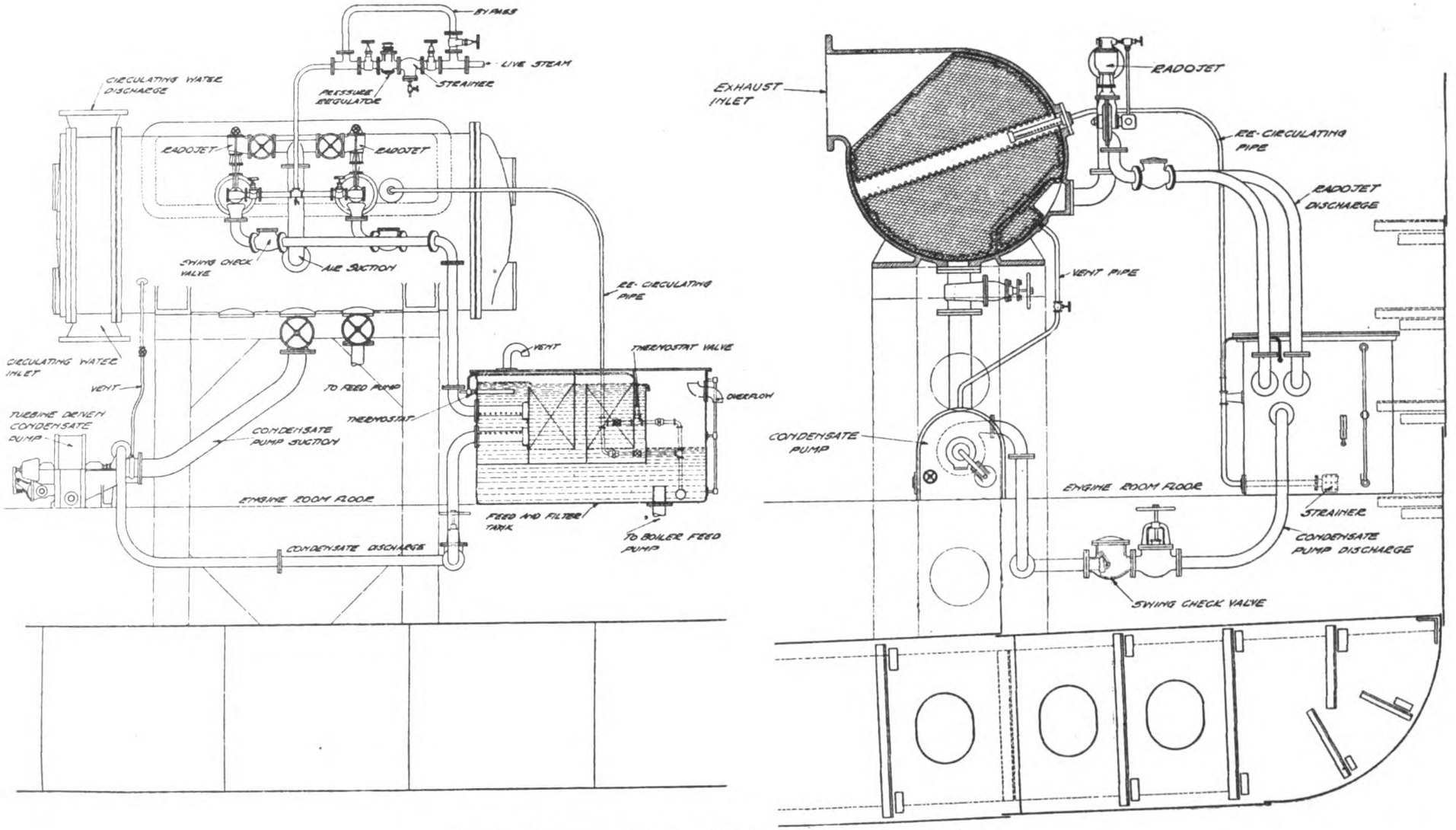

Fig. 12.—Air Ejector Installation for Marine Turbine Surface Condenser

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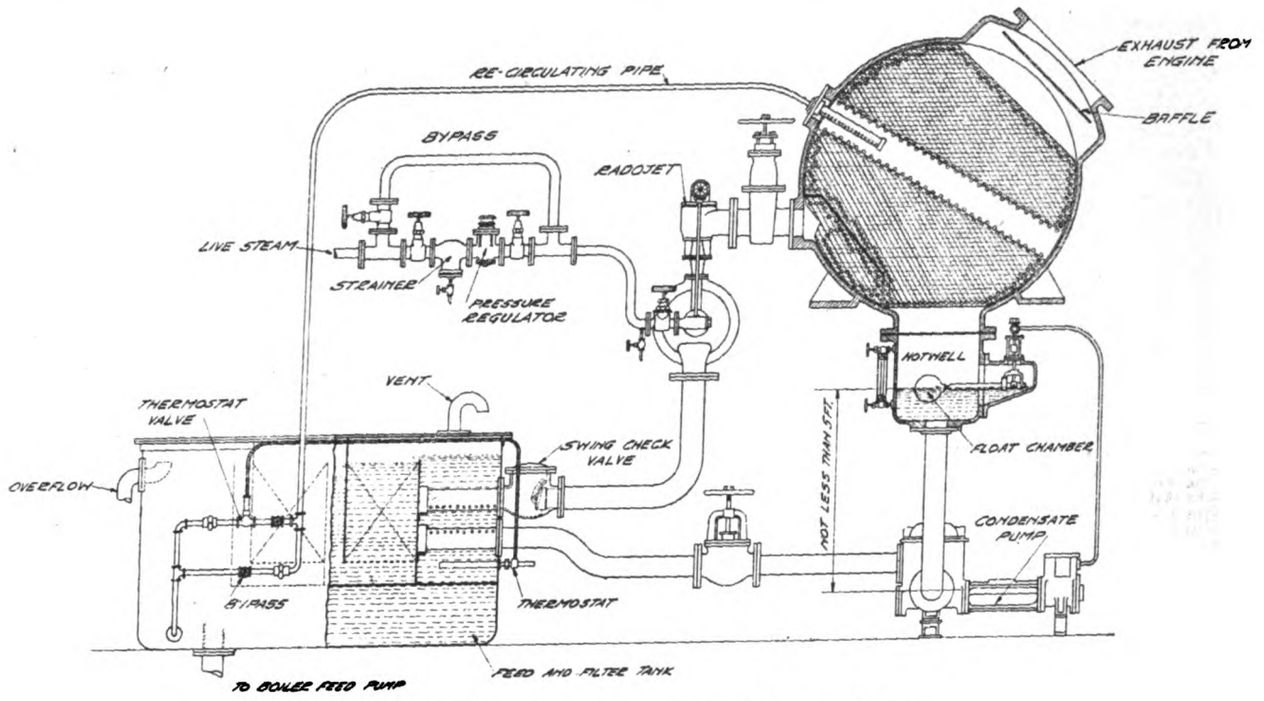

Fig. 13.—Air Ejector Installation for Marine Surface Condenser

individual installation), a thermostat is arranged in the feed and filter tank, controlling the thermostatically controlled valve. As soon as the water reaches the temperature for which the thermostat is set, the latter will open the thermostatically controlled valve and the vacuum will draw water through the re-circulating pipe into the condenser. By falling over the cool condenser tubes (the circulating pump, of course, being in operation), this water will be cooled and returned by the condensate pump to the feed and filter tank, thus preventing any further rise in temperature until the exhaust from the main engine again supplies sufficient condensate.

This arrangement makes the air ejector installation absolutely reliable, even if operated by inexperienced attendants. Starting is easy, as it requires only the opening of two steam valves, one for the turbine driving the condensate pump and one for the air ejector. During operation no attention is required, and, to shut down, only these two valves have to be closed.

A diagrammatic arrangement of an air-ejector installation with a direct-acting reciprocating piston pump is shown in Fig. 13. This arrangement is generally applied to marine reciprocating engine surface condensers, and is similar to that for marine turbine surface condensers already described. The only difference is that the speed of the reciprocating piston pump is controlled by a float arranged in the hot well.

The steam-air ejector was first tried out on board a ship about four years ago. It was feared that, by discharging the co-mingled steam and air into the feed tank, the amount of air absorbed by the feed water would be greater than that when using a reciprocating piston air pump. Comparative tests have shown that this fear was groundless. The amount of air absorbed in the feed water, when using the ejector, was 35 percent less than that when using the twin-beam air pump.

With this obstacle removed, the air ejector rapidly gained the confidence of shipbuilders and marine engineers, so that there are to-day to the writer's knowledge over five hundred ships built in this country equipped with steam-air ejectors. About one-third of these have beeen in successful operation for periods up to two years.

From this it would appear that the steam-air ejector to-day occupies a position among the air pumps similar to that occupied by the steam turbine among steam-operated prime movers. Its advantages, reliability and simplicity, are dominating factors which will gradually make its adoption as universal as that of the steam turbine.

New Motorship Added to the Glen Line

The 10,000 ton deadweight motorship *Glenluce,* built by Harland and Wolff, Glasgow, for the Glen Line, recently sailed on her first trip to China. The *Glenluce* is the eighth motor vessel built for this company and is of the standard 406-foot class, having a beam of 54 feet 2 inches.

This vessel is driven by two 1,500 horsepower, four-cycle Diesel engines constructed by Harland and Wolff. The normal speed at sea of the vessel is 11 knots, and the fuel consumption about 11 tons of oil a day, including that required by the auxiliaries.

A larger class of vessels will soon be put into commission for this company. Four which are building now will have a carrying capacity of 13,000-tons deadweight, and be fitted with twin-screw machinery of 6,400 horsepower.

The East Asiatic Company, Copenhagen, Denmark, has on order at the present time seven motorships, each with a carrying capacity of 13,600-tons deadweight. When launched, these ships, which are 485 feet in length, and fitted with twin-screw machinery of 6,000 indicated horsepower, will comprise one of the largest fleets of motor vessels in the world. The ships will have a speed of 12½ knots under full load at sea.

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Development of Warrior River Barge Canal*

Description of Terminals and Transfer Facilities—Cost of Water Transportation in Restricted Channels—Prospects for Future Development

BY MAJOR ROBERT S. THOMAS, CORPS OF ENGINEERS, U. S. A.

The more important terminals and transfer stations on the Warrior River barge canal are indicated in the following table:

TABLE III.—TERMINAL FACILITIES

Character of Facilities	Purpose for Which Used	Above Mobile	
		Location	Miles
Transfer station	Transfer of miscellaneous freight from boat to banks	Warrior River near Demopolis	235.9
Transfer Derricks	Handling lumber and miscellaneous material	Warrior River near Demopolis	299.5
Transfer Derricks	Handling lumber and miscellaneous material	Warrior River near Demopolis	334
Transfer derrick and wharf	Transfer of miscellaneous freight from wharf boats to barges	Black Warrior River near Tuscaloosa	364.5
Loading station	Loading coal, slag, coke, and pig iron onto barges	Black Warrior River near Holt	366.25
Loading station	Loading coal into barges	Black Warrior River	369.5
Loading station	Loading coal into barges	Black Warrior River	371.
Loading station	Loading coal into barges	Black Warrior River	413.25
Loading station	Loading coal into barges	Mulberry Fork of Black Warrior	420
Wharf	Handling of miscellaneous freight	Mulberry Fork of Black Warrior	420
Transfer station	Transferring freight from railroad cars to boats or barges	Locust Fork of Black Warrior	434
Loading station	Loading coal onto barges	Mulberry Fork of Black Warrior	438.75

In addition to these there are many inclined railroad tracks connected with small wooden warehouses for use of miscellaneous plantation supplies delivered by the packet boats between Demopolis and Mobile. The above mentioned terminals are privately owned and used generally for special purposes.

The coal tipples are of many varieties of design, Fig. 7 shows one type where the mouth of a creek has been bridged by an open trestle. The coal is brought several miles from the mines by rail and is loaded from bottom dump cars on the trestle to the barges in the creek below. Fig. 8 shows a bankside tipple for the transfer of coal from the mine to the barge.

The first municipal development on the river above Mobile has been that of the city of Tuscaloosa. The site is above Lock and Dam No. 12 about a mile and a quarter above the city at a suburban park, which has been purchased by the city from the local street railway company. This tract comprises about 200 acres and has about a mile and one half of river frontage. Connection with the city and with the railroads is by the tracks of the electric car line, the freight cars being handled by an electric engine to an exchange track in the city, where they are delivered to the respective railroads, who absorb the switching charges. There is now a passable highway, but the plans contemplate an improved highway of good grades and even surface.

Within reach of the barges in the river, of the railroad tracks and of the warehouse a 5-ton stiff leg steel guy derrick has been installed on concrete foundation. The derrick has a 100-foot boom and a 115-foot mast, upon a concrete pier which rests upon 17 foundation piles of 20-foot penetration. The stiff leg is 145 feet long. The derrick is figured to handle an ordinary capacity load of 15 tons and has been tested to 25 tons. The derrick was supplied by the American Hoist and Derrick Company, of St. Paul, Minn.

The present warehouse is the first unit of any number of warehouses that may be constructed later as the future may demand. It is located about 75 feet from the river bank upon cement piers which support a timber floor at an elevation well above any known high water.

*Concluded from March issue.

Since the installation of the derrick in June, 1919, considerable business has been done in transferring timber from the barges to the railroads. Pending a determination of actual operation costs a tentative price of 75 cents (3/1½) per 1,000 feet has been the charge for this service.

One of the best signs of awakened interest in the use of this inland waterway is to be seen in the shipments of steel that are now being made from Birmingham via Tuscaloosa terminal to the shipbuilding yards at the Chickasaw works near Mobile. The derrick at Tuscaloosa is not equipped as yet with a magnet so that the steel plates and rails are handled by slings. The first load of these plates was handled by a green crew in the rain, yet they were able to make one complete cycle every three minutes, which included hitching to the steel in the car, lifting and swinging and placing on the barge, unhitching and swinging back to the car. Three hundred tons were transferred in 8 hours at a field cost for crew and coal of $15 (3/2/6).

On top of the steel the barge load was completed with lumber. The tow handled by the *Volcano* included this barge of steel and lumber and three other barges of coal with top loads of lumber. The daily press of December 19 mentioned the first shipment of steel rails by all-water route from the steel mills of North Alabama to Cuba. The five carloads of rails were produced at Ensley, Ala., near Birmingham, transferred to the barges at Tuscaloosa, and from them transferred to one of the United Fruit Company's boats at Mobile for shipment to its plant at Preston, Cuba.

Birmingham Terminals

Although the city of Birmingham is some score or more miles from the Warrior river, the business interests of that city have recently incorporated a stock company for the development of the "Port of Birmingham." Press reports state that a capital stock of about $200,000 (£41,000) has been subscribed. The plans have received the required approval of the War Department and the contract was to have been let some days ago. The transfer station is to be located down stream from Ensley Southern Bridge, over the Locust Fork near Short Creek, about 419 miles from Mobile. On the east bank of the river at this place a side hill cut will be made into the steep hills that form this bank and upon this cut will be run several tracks parallel to the waterfront, but above high water. Loco-

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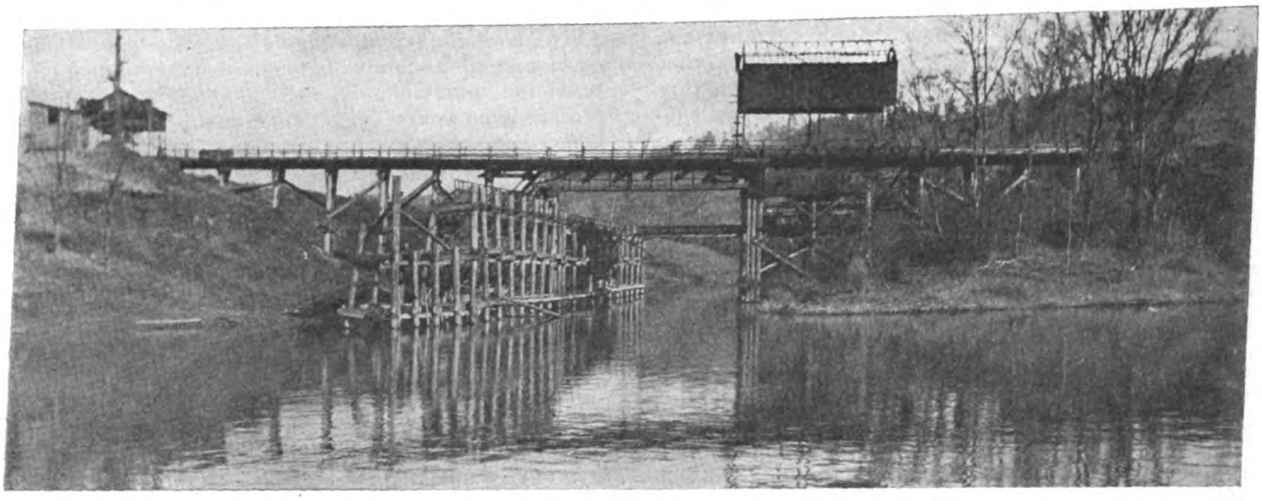

Fig. 7.—Coal Loading Station at Mouth of Cane Creek, on Mulberry Fork of Black Warrior River, Cordova, Ala.

motive cranes will be used for hoisting the steel containers and other heavy commodities. Ore bins with chutes will be provided for loading coal, iron ore, slag and such commodities. Steel anchor rods are to be placed in the rock to form anchors for guys to prevent the overturning of the locomotive cranes when handling heavy loads. These plans are for an ad interim station in order not to delay further the starting of the flow of traffic from Birmingham by way of the Warrior river, while further investigation is being made for a more extensive and more permanent layout.

A commodity survey indicates a possible expected annual tonnage through the Warrior river terminals of nearly one and one-half millions of tons inbound, valued at $16,145,500 (£3,400,000) and 162,000 tons outbound, valued at nearly eight million dollars (£1,640,000), the ratio of outbound to inbound being 9 to 1 in tonnage and 2 to 1 in value.

DEMOPOLIS

The Commercial Club of this city now has under advisement the matter of raising by local capital a representative stock company for the purpose of installing and operating a water terminal at that city. There is available city-owned property at the top of a very nearly vertical chalk bluff over the river and well above any known high water. The requirements would be simply a hoisting derrick of sufficient capacity to handle the steel containers, a warehouse and a short stretch of a spur track to connect with the railroad.

MOBILE

Mobile has its municipally-owned covered wharf that is open to all shippers on equal terms. A small charge is made to prevent abuse of the storage privilege. The city commissioners have agreed to install a derrick of sufficient capacity to handle the steel containers contingent upon the established use of these containers or the delivery of a certain number. In the meantime there are available one or more derrick boats in the harbor.

There is much talk in the local press about the etsablishment of a modern coaling station in the harbor for bunker and export purposes. The method of procedure proposed has been for the United States Railroad Administration to construct, own and operate the plant underwritten by the coal operators who are supposed to guarantee the success of the undertaking. No final conclusion has yet been arrived at.

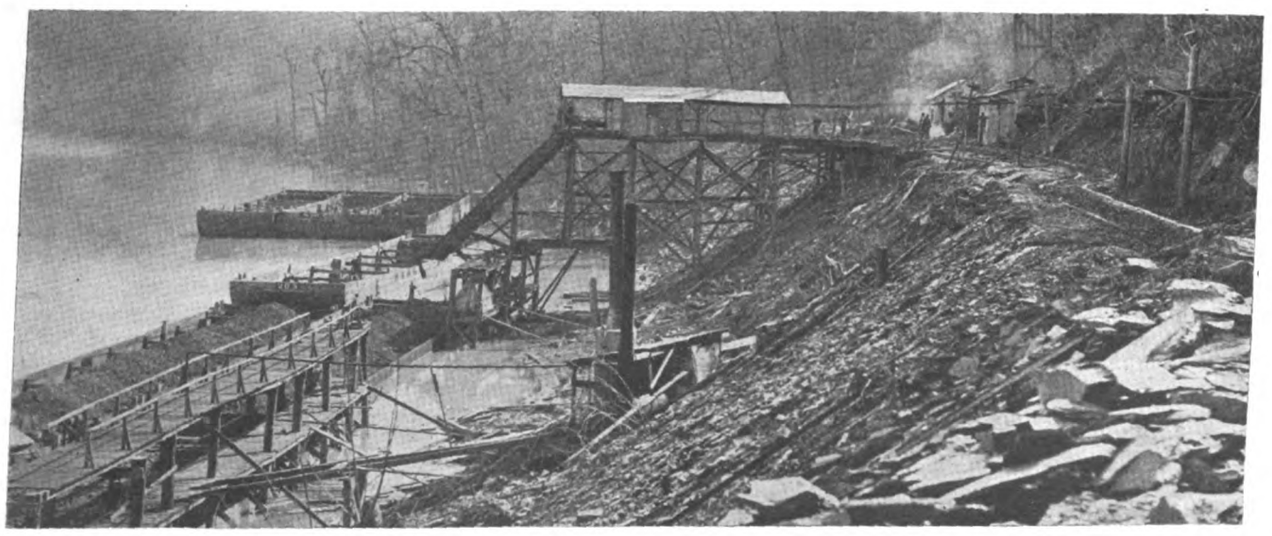

Fig. 8.—Coal Loading Station on Mulberry Fork of Black Warrior River, Ala., a Mile Above Mobile, Ala., Looking Upstream

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At the present time the actual costs of operating the boats of the Railroad Administration and of the packet lines are not available, but a very interesting and a very representative study of this phase of the problem was published by G. K. Little, United States assistant engineer on the Warrior river, in the *Professional Memoirs, Corps of Engineers U. S. A. and Engineering Department at large*, for May-June, 1916. The study was made for the particular purpose of obtaining data bearing upon the problem of economics of restricted channels.

Cost of Water Transportation

Accurate data were obtained as to the volume of traffic and the length of time consumed in the round trip over the most tortuous and most tedious portions of this canalized river that portion inclusive of Dam 17 to Dam 4. This round trip between the two dams inclusive required travel over 314 miles, involved thirty lockages and involved handling and flanking through the narrowest and crookedest part of the river. The time of these observations covered a period of four months, of which two months were during low water and two months at high stage. The costs of operating were based upon known costs for similar units and items as paid on government work. The estimates for three western river sternwheel towboats with two barge tows, average load, between 1,000 to 1,200 tons; average time of round trips, between four and six days; time of best round trips, 3 days and 3 hours, give the costs per ton mile for the average round trips for the three towboats respectively 2.74 mills, 1.99 mills, and 2.23 mills respectively; for the best round trip 2.06 mills, 1.47 mills, and 1.53 mills per ton mile, respectively. For the larger sternwheel towboat with three barge tows; average load, 1.763 tons; average time for round trip, five days and five hours; best time for round trip, five days and one hour with a load of 1,800 tons—for this the cost was 1.72 mills per ton mile for the average round trip and 1.63 mills per ton mile for the best round trip.

The data for the self-propelled steel barges previously described covered thirty round trips; the average load for the several barges were from 637 to 797 tons; average time per round trips, 3 days and 18 hours to four days and three hours; the time of best round trips, two days and eighteen hours to three days and ten hours; cost per ton mile per average trip, from 2.04 mills to 2.32 mills. Lowest cost per ton mile for the best trip was 1.45 mills per ton mile. These costs included 6 percent interest in the first cost of plant, and 6½ percent insurance, 20 percent depreciation and maintenance and fixed expenses of operation.

It is interesting to note that costs for the sternwheel towboats and the self-propelled barges were practically the same, about 2¼ mills per ton mile. Applying these rates to the distances from the mines to Mobile and to New Orleans the water cost would have amounted to 94½ cents (3/11¼) and $1.305 (5/5¼) per ton respectively, which compared to the rail rates on export and bunker coal of $1.00 (4/2) to Mobile and $1.25 (5/2½) to New Orleans would hardly justify mine owners with rail connections in attempting to use the river route. Mr. Little points out that these estimates are based upon the costs of traveling over the slowest portion of the route. By taking into consideration the greater speed actually obtained in the deeper and wider river after passing the lower lock, the costs were in 1916 approximately 74 cents (3/1) per ton delivering at Mobile and $1.00 (4/2) per ton for delivering at New Orleans, including toll charges of the Lake Borgne Canal, or a cost of about 20 percent less than the rail rate.

Since Mr. Little's study was published in 1916 the increased cost of labor and of supplies has no doubt increased the operating costs by at least 20 percent. On the other hand under the present management and with the increased experience of the crews and management certain economies in methods have been effected, though it is extremely doubtful that these can offset the great increase in the cost of labor and supplies. The above estimates were correctly based upon the cost per round trip, with the return trip empty. Nor do these estimates include interest on the nine million dollars (£1,850,000) expended by the Federal Government in development of this canalized river nor the quarter million dollars (£51,250) annum required to operate and care for this system of locks and dams.

It should not be overlooked that the above estimates of the actual cost of transportation by water are compared with the existing freight rates *as charged* and that very little information is available as to the *actual cost* to the railroads of the transportation of same commodities to and from the same points. It is well known, however, that to points where there has existed actual or potential water competition the freight rates on like commodities are less than to points without such water competition, even though the distance from point of origin to destination be ever so much less. And it is also well known that under existing system of charges many railroads are piling up a deficit.

The existing condition of affairs would appear to confirm the obvious conclusions from the foregoing; for at the present time with an all-year-round navigation of over 6-foot depth, with an established boat line operating with economy and under intelligent supervision, with unlimited production of steel and coal at one end of the waterway and a practically unlimited demand for the same commodities at the other end, the traffic on the river is practically limited to the output of about three mines which are situated upon or only a short distance from the water's edge, to the transportation of logs and timber and to miscellaneous merchandise to and from those planters who have no railroad facilities within reasonable reach.

Conclusions

After nearly fifty years of investigation, experimentation, maintenance and progressive construction the Federal Government has provided for the Southern coal and iron region of the Birmingham district and for the timber and farming sections of western Alabama a canalized river that offers for over 400 miles facilities for navigation not possessed to so great a degree by any other system of inland waterways in the United States at a cost to date of over 12 million dollars (£2,460,000) for improvement and maintenance and at a cost of over a quarter million dollars (£51,250) per annum for the continued maintenance, care and free operating of the same.

This waterway has the following advantages:

(a) Slack water except at times of floods.
(b) A practical depth of 8 feet.
(c) A width of channel of not less than 125 feet in a few of the bends, but with generally a minimum width of 150 feet.
(d) Navigation possible the year round, uninterrupted by ice or by floods or by low water.
(e) Production of coal and steel at the upper end—commodities especially suited for water transportation.
(f) Market for these commodities at the lower end.

With all of the foregoing advantages, but with the

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present railroad rate structure, and with the present equipment and with one-way traffic, water transportation is barely, if at all, profitable to the water carrier.

If the business and commerce of the country are to derive the full advantages from the large expenditure of public funds and from the almost ideal system of navigable waters resulting therefrom, all or a portion of the following steps are necessary:

(1) Re-adjustment of existing "water compelled" freight rates, due consideration being given to

(a) Costs of service to the railroads.
(b) Cost of similar service to the water carrier.
(c) Equity and fairness to those commodities not situated upon the inland waterways.
(d) Water competition must be actual rather than potential, in order to be considered.

(2) Joint rates between rail and water carriers—on a fair and equitable basis. In general most river banks are either barren hills or overflowed fields and are not especially productive. Traffic originates at a distance from the river and often the ultimate destination is at a distance from the water. The boats cannot leave the water to go and get these commodities. The commodities must be brought to the boats. The charge for the delivery of these commodities from the producer to the water front should be reasonable and non-discriminatory.

(3) Adequate terminal facilities for the storage, protection and economical transfer of the commodities from the land to the boats and vice versa.

(4) Improved and more economical plant and design of the water carriers.

(5) Increased volume of water-borne traffic with a corresponding reduction in overhead rates.

(6) A large increase in the amount of return cargo to be handled.

PROSPECTS OF THE FUTURE OF THIS DEVELOPMENT

The navigable condition of the waterway is already a practical fact, indeed navigation on this stream is accomplished with less difficulty than on other river systems in the United States.

Terminal facilities have been installed at one city, Tuscaloosa, and are being successfully operated. The city of Birmingham is now undertaking in earnest the establishment of its terminals. The prospects are that sooner or later the city of Demopolis will follow suit and the city of Mobile is committed to the establishment of terminal appliances whenever the need for them becomes positively evident.

Towboats and barges designed in the light of most modern experience are now being constructed for the United States Railroad Administration for operations on this river, and one of these towboats is soon to be launched.

The establishment of derricks at the principal terminals, together with the use of steel containers, promises to afford a more economical method of transfer and to eliminate the losses due to weather and theft that have so militated against water transportation in the past.

Joint rail and water rates have been authorized and are now being prepared for publication, whereby commodities can be shipped from Mobile and New Orleans to points in northern and central Alabama and northern Mississippi by water to Demopolis and Birmingham and thence by rail.

The principle of a 20 percent differential under the existing rail rates has been established for the water rates.

All of the above will greatly aid in increasing the upstream volume of traffic by permitting safe and economical shipments of such perishable products as salt, sugar and rice from Louisiana, and coffee, grain and hay, which are collected at New Orleans and Mobile. Demopolis being in an agricultural and stock-raising section and a possible jobbing point, the establishment of terminals there is especially desirable as a factor for increasing the volume of upstream traffic.

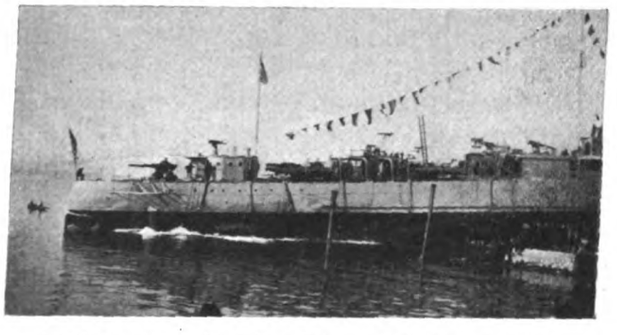
In sum, the present indications are that the local business interests are just beginning to awaken to the opportunity that lies at their door; and the logical and carefully considered steps that have been taken indicate an intelligent and well-guided progressive public interest.

The prospects for the future are indeed encouraging.

Launching of Destroyers at Newport News

ON February 14 two destroyers for the United States Navy were launched at the yard of the Newport News Shipbuilding & Dry Dock Company, Newport News, Va. The first launched was the *Abel P. Upsuhr,* and the second the *Hunt.*

These were the first ships ever launched from these ways, as they were a part of the Newport News' war programme, and the vessels were much nearer completion than is usual at this time of launching, due to the fact that no other vessels were waiting to use the ways.



U. S. S. *Hunt,* Launched February 14, Newport News Shipbuilding & Dry Dock Company

Both destroyers are of the type being built at this and other yards, the Navy numbers being 194 and 195, respectively.

Newport News Shipbuilding & Dry Dock Company Building 20,000-Ton Tankers for Standard Oil Company

TWO oil tankers, of 20,000 tons deadweight capacity each, are under construction for the Standard Oil Company of New Jersey at the yards of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va. These vessels are 555 feet long between perpendiculars, 75 feet beam and 43 feet 3 inches depth. They are designed for a speed of 10¾ knots, and will be provided with two sets of triple expansion engines with cylinders 23 inches, 39½ inches and 68 inches diameter by 45 inches stroke, capable of developing 3,800 indicated horsepower. Steam will be supplied at a working pressure of 200 pounds per square inch by three Scotch boilers each 17 feet diameter and 12 feet long. In each vessel will be installed four pumps, supplied by the National Transit Pump and Engine Company, each having a capacity of 2,200 barrels per hour.

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National Marine Week

NATIONAL MARINE WEEK (April 12-17) stands for American independence on the sea. It marks the awakening of the American people, as a nation, to their obligations and opportunities for extending their commerce and influence to the four corners of the globe by American ships and American agencies. It signifies the restoration of the American merchant marine in foreign trade. Commercially, industrially and politically, it marks the beginning of a new era in the life of the nation, the benefits of which are not confined to marine interests alone but which extend to every phase of the country's activities. National Marine Week stands for independence on the sea! Where do you stand?

Motorship Building

THAT the United States with its great natural advantages in the production of fuel oil should lag so far behind other nations in the building of motorships is astounding in view of the fact that the feasibility, reliability and economy of motorships have become so thoroughly established in other countries less favored in the matter of fuel oil supplies. Between 110 and 120 motorships, the majority of which are about 10,000 tons deadweight, are now on order in European shipyards. As a matter of fact, every marine oil engine manufacturer in Great Britain and on the Continent has so much work on hand that it is impossible to undertake new orders or give deliveries within a year or eighteen months. Ninety percent of these vessels are of standardized types, falling into three general classes; first, vessels of 13,000 to 13,500 tons; second, vessels of 9,500 to 10,000 tons, and, third, vessels of about 6,500 tons deadweight. More than four-fifths of the engines to be installed in these ships are of the Diesel four-cycle type. As evidence of the reliability of this type of vessel, the first large Diesel-engined motorship built, the *Selandia*, constructed by Burmeister and Wain at Copenhagen, Denmark, has been in regular service for eight years on 30- to 40-day non-stop runs covering in all some 400,000 miles without serious breakdown. Other vessels are giving equally reliable service, and it is significant that each of the shipowners who has gained experience with motorships, when placing repeat orders, invariably contracts for vessels fitted with Diesel engines. As our London correspondent points out elsewhere in this issue, had motorships been unreliable or costly in upkeep, this condition would not exist. Although some progress is now being made in the United States in the building of large Diesel engines for ship propulsion, the fact remains that American shipowners and shipbuilders have been far outdistanced in this branch of marine engineering, and have a heavy handicap to overcome in order to match the lead of their rivals across the sea.

The Institution of Naval Architects

AMONG the events of special interest during the past month was the annual meeting of the Institution of Naval Architects held in London on March 24 to 26. The programme of this meeting, which dealt largely with naval subjects, the economic situation of the shipbuilding industry in Great Britain and special developments in marine engineering, included the following papers:

"The Battle Cruiser *Hood*," by Sir Eustace D'Eyncourt, director of naval construction.

"German Submarines," by A. W. Johns, of the Royal Corps of Naval Constructors.

"Experimental Work in Connection with Devices for Catching Submarines," by G. S. Baker, of the National Physical Laboratory.

"Notes on Our Economic Position as a Shipbuilding Country," by Sir Alfred Yarrow.

"Further Notes on the Dimensions of Cargo Vessels," by J. Anderson.

"Freeboard and Strength of Ships," by J. Bruhn.

"Stabilization of Ships by Means of Gyroscopes," by P. R. Jackson.

"Yawing of Ships Caused by Oscillation Among Waves," by Professor K. Suyehiro.

"Effect of Size Upon the Performance of Rigid Airships," by C. I. R. Campbell and C. H. May, both of the Royal Corps of Naval Constructors.

"The Effect of Holes, Cracks and Other Discontinuities in Ships' Plating," by Professor E. G. Coker and A. L. Kemball.

"Experience and Practice in Mechanical Reduction Gears," by Engineer-Commander H. B. Tostevin, R. N.

"Balancing of Rotors and the Determining of the Position and Amount of the Balancing Weights," by J. J. King-Salter.

"Turbulent Fluid Motion and Skin Friction," by Professor T. H. Havelock.

Several of these papers will be printed in full and others in abstract form in coming issues of this journal.

The Latest United States Battleship

SINCE the signing of the armistice, work has been going on apace in the completion of the capital ships authorized by Congress in 1916, the consruction of which was held up during the war. The latest vessel of this type to take the water is the superdreadnought *Maryland*, which was launched at the yards of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va., on March 20. The *Maryland* is the fourth capital ship of the Navy to be equipped with electric drive and is a sister ship to the *California*, launched in November at the Mare Island Navy Yard, California. The *Maryland*, however, has the distinction of being the first vessel to mount 16-inch guns, and in this respect will represent a distinct advance over other ships of this class, as her main battery of eight guns will have a range greater than that of any other American warship. The vessel itself is

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624 feet long, displaces 32,000 tons, and is designed for a maximum speed of 21.5 knots. The electrical propelling machinery, supplied by the General Electrical Company, consists of two turbo generator sets rated at 11,000 kilowatts each; one control board; four 7,000-horsepower propelling motors of the induction type, and six 300-kilowatt exciter sets. The capacity of the complete power plant for propulsion is 28,000 horsepower. In most respects the propelling machinery follows that of her predecessors, the *California* and *New Mexico*, which was fully described in our May, 1919, issue.

Shipbuilding and the Merchant Marine

IN the shipbuilding returns published in this issue, showing the amount and character of work now in hand in American shipyards, the figures give every promise of the continuation of the prosperity which the shipyards have enjoyed as a result of the war. By the end of this year the Shipping Board programme will have been practically completed. In fact, in many of the yards this work is even now practically finished, but in almost every case, especially in the steel shipyards, the volume of new business for private account is filling the gaps made by the completion, cancellation or suspension of Shipping Board contracts, so that the yards are continuing to operate at full speed. Over a million and a quarter gross tons of steel ships are now under construction for private account, and at the present rate of progress the volume of this construction should amount to at least two million gross tons in June.

The optimism which characterizes conditions in the shipbuilding field is borne out by similar conditions in the shipping field, where the volume of business and the scale of freight rates insure prompt returns on shipping investments. Here, however, progress is hampered by the constant delay of Congress in establishing a definite Government policy for the operation of the American merchant marine and the disposal of Government-owned ships. The suggestions and opinions from leaders in the shipbuilding and shipping fields bearing on these questions, published in this issue, show that the demand for Government aid or assistance in some form or other is practically unanimous, but between the shipbuilders and shipowners there is a difference of opinion as to how this assistance should be given. The shipowners ask for the sale of Government-owned ships at a price of about $100 a ton, in order to place their investment more nearly on a par with that of the existing fleets of other countries, which were constructed before the war at low cost. On the other hand, the shipbuilders enter a strong protest against the disposal of Government ships at prices below current market values, and have unanimously endorsed a plan proposed by Homer L. Ferguson, president of the Newport News Shipbuilding and Dry Dock Company, providing for discriminating duties in favor of American shipping as a means for the advancement of the American merchant marine along lines beneficial not only to the shipbuilding industry but also to shipping and commercial interests, as well as to labor and the public.

"In seeking a Government policy," Mr. Ferguson asserts, " it seems that one which can be made applicable in all fairness to the commerce of any country would be the best one. That policy, in brief, is one which will give preferential treatment to our own ships in our own trade with any given country and will give to the vessels of that country the same treatment. On the other hand, when the vessels of a country which is not interested in the trade except as a common carrier seek to enter that trade, known as the indirect trade to such country, there shall be imposed upon such common carrier an additional burden. The principle underlying this policy is that the trade between any two countries is essentially their own business and that every country should have a merchant marine proportionate to its needs, in order that it may maintain both its economic and political independence."

A New Application of Electric Propulsion

MECHANICAL power was first applied to marine transportation in 1807 by Robert Fulton on the Hudson River. In the something more than one hundred years which have passed since then, steam navigation has extended to all navigable waterways of the world, and the volume of commerce that has been handled in this way has far outdistanced any possible conception or dream of its originator. Now, however, comes another inventor, William T. Donnelly, of New York, who, as described on another page of this issue, has successfully made the first application of mechanical power changed into electricity on one vessel, transmitted to another and there applied as mechanical power for the propulsion of that vessel.

The inventor of this new development, like Robert Fulton, has dreamed his dreams and, after many years, has been able to show to others the result of his work and planning. The broad and far-reaching conception and possible applications of this method of applying power for marine transportation are very clearly set forth. While they may not be entirely conclusive to the conservation members of the engineering profession, they are certainly enlightening and will undoubtedly be appreciated by all those interested in this particular field of engineering development. The inventor's long experience and notable success in other lines of marine engineering, many of which have been described and illustrated in this paper, certainly entitle his work to very careful consideration in view of the possibilities for the practical application of this means of generating, transmitting and utilizing power for marine transportation.

Certainly the present time would seem most opportune for the bringing out of a new system of transportation, promising so much greater dispatch, reliability and economy than anything heretofore applied to our harbors and inland waterways. As a matter of fact, very definite plans are now being made for the broad application of this system to inland waterway transportation, beginning with the New York State Barge Canal.

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Letters from Marine Engineers

Discussion of the Design and Handling of Marine Engines, Boilers and Auxiliaries—Breakdowns at Sea and Repairs

This department is open to all readers of the magazine for the discussion of affairs in the engine room. All letters published are paid for at regular rates. Your ideas or experiences will be mutually helpful and interesting to other engineers. Write your letter now.

Running Shaft Lines in Steamships Under Construction

AS every article that I have seen regarding the running or laying out of shaft lines in steamships under construction recommends or describes the use of piano wire or light shutters, it is thought that the method used by the Alabama Dry Dock & Shipbuilding Company, of Mobile, Ala., might prove interesting.

When we are ready to bore a shaft log, the exact height of the center of the shaft at the engine foundation is laid off and a support is placed at this height. Then the height of the center of the shaft at the rudder post is also marked and a chalk line is stretched between these points. A number of wooden stands with adjustable arms are then built and placed along the shaft tunnel about 20 feet apart, and the chalk line is run over these arms, which enables the line to be raised or lowered. Next, an engineer's field level is set up, and the line of sight of the instrument is made parallel to the true shaft line by reading on the two ends of the chalk line which have been fastened at proper heights, as stated above.

After the line of sight of the instrument has been made parallel to the shaft line the adjustable wooden arms over which the chalk line runs are raised or lowered as indicated by the level, until the chalk line is parallel to the line of sight. The chalk line is then pulled tight, and is the true shaft line. Measurements for boring the shaft log are then taken from this line in the usual manner.

This method of running shaft lines was used by the Alabama Dry Dock & Shipbuilding Company during the construction of the mine sweepers *Swan*, *Whippoorwill* and *Bittern*, also during the construction of the Ferris-type steamships *Banago* and *Alta*, and proved to be very accurate and efficient.

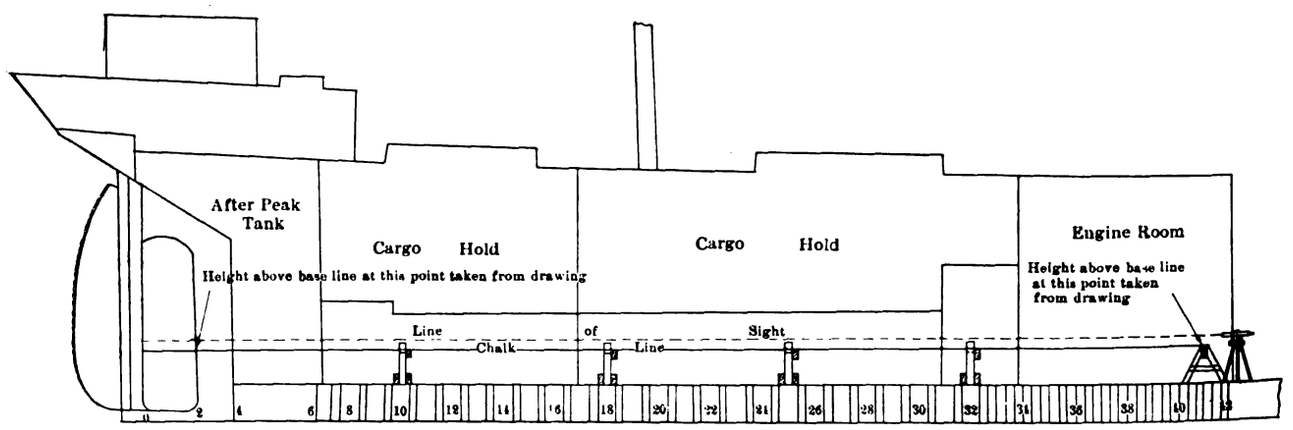
As a matter of fact, the chalk line was not necessary. The shaft line can be run with the level alone; but it was found more satisfactory to use the chalk line, as the machinists could take as many measurements as desired without the assistance of the instrument man, and, of course, have more confidence in their own observations. The accompanying sketch shows how chalk line was used.

Mobile, Ala. T. A. JOHNSON,
Field Engineer, Alabama Dry Dock and Shipbuilding Company.

Lathe Tool Equipment on Board Ship

I notice that the lathe tool equipment on our ships still consists of a handful of old-fashioned heavy forged tools, ordered probably by a purchasing agent whose knowledge of the requirements is perhaps limited. The writer has had the miserable experience of trying to get out work needed in a hurry with the poor assortment of tools supplied, and in the most cases they wont even fit the tool-post.

It would be a boon to the machinists on board our ships for some firm to make up a useful list of modern tools of equipment, making sure that they are suitable for the lathe tool-post. Take the case of the firms supplying the lathe, they could arrange to supply the whole equipment to cover the range of work usually occurring on board a ship; it is not wide, and a compact list of tools could be easily made up that would save lots of time, worry and expense.


After Peak Tank
Cargo Hold
Cargo Hold
Engine Room
Height above base line at this point taken from drawing
Height above base line at this point taken from drawing
Line of Sight
Chalk Line

Sketch Showing Shaft Line on Ferris Ship. Note Position of Field Level

The Armstrong Bros. could make up a most useful list, or the Fairbanks Company, consisting of the three bar boring tools, tool holders, cutting-off tools, threading tool, lathe dogs, clamps, Jacobs' chuck, lathe arbors ¾-inch to 2-inch Nicholsons; centering drills, Fairbanks, Fig. 7310-D style; a set of lathe arbors, Fig. 5430-B, Fairbanks, with a grinding wheel to suit ½-inch arbor, ½-inch face, 6-inch diameter, making sure that all tool bits and cutting-off tools and threading tools were ordered to suit holders and include a couple of dozen assorted bolts and a small angle plate.

The cost of a decent set of modern lathe tools would not

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be a great deal more than the old-fashioned bunch of junk that usually accompanies the lathe on board, and would be of some use when required.

Bath, Me. Thomas Mateer,
Foreman Machinist, Texas Steamship Company.

Wreck of the Liberty Glo

THE severe poundings which the modern ship will stand, and an American-built ship, a war bride if you please, are well illustrated in the case of the *Liberty Glo*, a Hog Island ship of 7,800 tons deadweight, which, on December 5, 1919, hit a submerged mine in the North Sea just off Branderis on the northern coast of Holland.

Cut from waterline to waterline through No. 2 hold, the master was able to get her into shallow water and held her there for fourteen hours, awaiting the promised assistance which never arrived. Within sight of land, right off a lighthouse and lookout station, burning distress signals of every sort, yet no visible effort was made to render the ship any assistance. When it had become evident that the ship could hold together no longer in the increasing gale, orders were given to take to the boats. The ship parted, the port side giving away first, covering

Fig. 1.—Bowless, Severely Pounded, but Still a Ship

the sea with fuel oil, bales of cotton and barreled oil, and then the starboard side let go.

The after part of the ship, driven by wind and seas, a dark, desolate shape, its hopelessness accentuated by one lone light playing around the bridge, for the master had remained with his ship, soon disappeared into the breakers. There she received a beating such as few ships ever take and still retain the semblance of a ship. After the storm had subsided and when she could be boarded from the shore it was found that she was still a ship, intact, and well worth salving.

Fig. 2.—Looking Into Hold

Fig. 3.—Method of Boarding the Ship

This, however, was the first of many poundings she was to take. She now rests high up on the beach, as can be seen from the snapshots, having been driven there by three successive storms, each one expending its fury upon the ship but unable to smash her. Her boiler and engine rooms remain intact, the pumps are used frequently to keep her dry, and with any sort of weather she will again sail the seas.

Fig. 4.—Captain and Officers of the Ship High on the Beach

The forepart has been driven up onto the beach about two miles from the after part and is slowly working its way into the sand, a total loss.

A word of praise is due the memory of the chief engineer, George H. Weston, who died from exposure in a lifeboat. During the trying moments right after the ship had been hit and while it was yet unknown what she would do, he stayed by his post, giving all that he had in the successful effort to get her in to the coast.

E. B. Perry, Third Officer,
S. S. *Liberty Glo.*

Nes op Ameland, Nederlands.

Cleaning Out a Squirt Can

It is a very rare thing to see anybody clean out a squirt can, yet everybody knows that no receptacle will always keep clean. How the dirt gets into the cans is hard to say. The oil itself has some dirt in it, then dust settles down through the spout. Also, when a machinist pushes the spout into the oil holes in the apron of his lathe, he scrapes up the dust and dirt in these holes. Anyway, the dirt gets there and it is no easy matter to clean out a squirt can. Gasoline (petrol) and a few No. 8 shot will do the work; so will a jet of steam, but to do the work in this way requires a special rig. The spout must be cleaned also.

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When a man drops a full squirt can it is quite sure to hit on the rim and, of course, is made to leak. The machinist starts for the soldering iron and tries to solder the leak, with the idea that he is saving the boss money. As the metal is oily, the solder does not flow well, but at last a big gob of solder sticks to the can. It is botch work and, as a matter of fact, makes the article cost the boss about four times as much as buying a new can.

The thing to do with a dented can is to turn it back to the store room. It does not pay to fool with it.

A squirt can usually goes with some machine, and it looks strange on a drawing board. When asked why the can was on the board, the draftsman made an ink line on the edge of the paper, then pointing the spout of the can at the line he pressed the bottom rapidly and the ink dried almost as if by magic. That was a new idea.

Norfolk, Va. George Sheath.

British Standard Ship

(*Concluded from page 276.*)

for two wireless operators. The officers, engineers and chief steward are quartered in the saloon house. The engineers' mess room and petty officers' quarters are in side houses on the shelter deck. The crew's quarters are aft in the 'tween decks, access being obtained from the deck house on the shelter deck.

Structural Arrangements

The vessels are built under the special survey of Lloyd's Register of Shipping according to the shelter deck rule, and classed 100 A-1. The keel is of the flat plate type, with overlapping butts and a centerline keelson 3 feet in height. The vessel has 6 inches rise of floor, 5 feet radius bilge and 7 inches tumble home at the shelter deck. The bilge keels are 9 inches deep, of the usual tee-bar and bulb plate type, and are fitted amidships on each side for a distance of 100 feet.

Solid plate floors are fitted on every frame, but are lightened by large manholes throughout the double bottom. One continuous line of intercostals on each side of the centerline is carried as far fore and aft as practicable, with an extra line on each side under the engines, and an extra half-depth intercostal forward of the three-fifth length amidships, to take up panting stresses.

The side frames are of bulb angles, spaced 24 inches apart throughout, and carried to the upper deck and shelter deck, alternately. Intermediate angle frames are fitted in the 'tween decks for one-fifth of the length forward and one-eighth of the length aft, and are scarfed to the main framing. No side stringers are fitted except forward, to prevent panting. The shelter and upper deck beams are bulb angles, fitted to every frame and supported by a centerline girder. The girders are in turn supported by widely spaced pillars, formed of four angles, leaving spacious holds with the least possible obstruction to the stowage of cargo. The decks are of steel throughout, and are covered with "litosilo" in way of the accommodations.

Equipment and Steering Gear

Every provision has been made for the rapid handling of cargo, each hatch being served by two derricks capable of lifting 5 tons each. Each derrick is worked by a separate 7-inch by 10-inch Clarke-Chapman winch. One derrick at No. 2 and one at No. 3 hatch are capable of lifting 10 tons, special goosenecks and sockets being fitted to the masts for housing them when handling heavy lifts. Preventer stays are also provided for supporting the masts when the heavy derricks are in use. The steam windlass was supplied by Messrs. Emerson, Walker & Thompson.

A steam steering gear, supplied by Messrs. J. Lynn & Company, is fitted at the aft end of the engine room casing, and connected to the steering quadrant by means of rods and chains. Relieving gear of the Taylor-Palaster type is fitted to the steering quadrant. Auxiliary tackle is also installed for working the rudder by means of the two after winches in case the steering gear breaks down.

Propelling Machinery

The propelling machinery, which was installed by Messrs. H. & C. Grayson, Ltd., consists of a set of triple-expansion, inverted, direct-acting, surface-condensing engines, with cylinders 21 inches, 34 inches and 56 inches diameter by 36 inches stroke, designed to develop 1,100 indicated horsepower at sea.

Steam is supplied by two single-ended, cylindrical boilers 15 feet 6 inches in diameter and 11 feet 6 inches long, working at a pressure of 180 pounds per square inch. The boilers work with natural draft, and have a total heating surface of about 5,100 square feet and a grate surface of 138 square feet.

The *Cervantes* on her trial trip steamed at 12.25 knots, and on her maiden voyage averaged 10.4 knots on a coal consumption of about 19 tons per day.

BOOK REVIEW

Hendricks' Commercial Register of the United States for Buyers and Sellers. (Twenty-eighth Annual Edition, 1919-1920.) Size, 7¼ by 9¾ inches. Pages, 2,541. New York, 1920: S. E. Hendricks Company, Inc. Price, $12.50.

THE 28th annual edition of Hendricks' Commercial Register of the United States for Buyers and Sellers for 1920 has just been published, after being delayed for two months by the strike of the printers in New York. The new edition contains several improvements, the most noticeable being the new method of exterior indexing by coloring the front edge red, white and blue, to indicate the different main sections of the book.

First is blue on which is stamped the words "Trades Index." This is a section of 162 pages in which every product listed in the book is indexed and cross indexed for ready reference. The red section is the main classified trades list. It contains 1,813 pages listing over 18,000 different products. In the present edition we find over 1,200 new headings, including many headings completely covering the chemical industry. The third section of the book, as indicated by the white edges, contains 216 pages listing the trade names, under which products are manufactured, with the name and address of the manufacturer. The second blue section is the alphabetical section of 487 pages, containing all the names in the book in one alphabetical list with addresses, and their main line of business. This is followed by the index to advertisers of 20 pages, containing a full list of branch and foreign offices following each name.

It is an excellent work, a copy of which should be in every sales and purchasing department. For the former it contains complete lists of all prospective customers, and for the latter it shows at a glance the producers of any product which may be required. The list of trade headings covers from the raw material to the finished article all products connected with the electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, chemical, railroad, steel, architectural, contracting and kindred industries, and the firms listed cover producers, manufacturers, dealers and consumers.

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Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding Will Be Answered in this Department

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

Large Concrete Vessels

Q. (1,035).—Are concrete ships more rigid than steel? If they are flexible, does the working of the ship by hogging and sagging in a heavy sea have any effect on the concrete? What effect has oil on concrete? Have any ships of 7,000 tons or over been built in the United States and powered by heavy oil engines? Kindly furnish the following information concerning the 7,500-ton concrete oil tankers building at Mobile, Ala., for the Emergency Fleet Corporation, viz., sizes of main engine and auxiliaries, piping arrangements for pumping cargo, bulkhead connections of the piping, sizes of heating coils in tanks, i. e., their ratio of heating surface to cubical contents of cargo tanks; method of securing deck machinery to deck, also fastenings of stern tube and rudder post to hull.

A. (1035).—No tests have been made to the writer's knowledge upon the deflection of concrete ships. Concrete beams have been tested, and one type showed a deflection of 1/720th the span, the steel being under 16,000 pounds per square inch stress (Technical Papers, Bureau of Standards, No. 2, test by Humphrey and Losse). It would appear probable that the deflections of steel and concrete ships are of about the same magnitude, much less than wooden ships under similar conditions. If the bond stresses or tensile stresses are too high, thus allowing vessel to deflect too much, i. e. work, trouble would be developed showing as cracks in the concrete.

In regard to vessels propelled by heavy oil engines, the United States has built only one of over 7,000 tons, namely, the *Maumee*, a steel naval tanker of 15,000 tons displacement, having two 2,500-brake-horsepower, six-cylinder, two-cycle Diesel motors.

Mineral oil, according to Mark's Mechanical Engineer's Handbook, does not affect the strength of concrete. Although it is customary to cement the bottom of salt and fresh-water tanks aboard ships, it is not considered wise to cement wash tanks containing oil. However, inaccessible parts of tanks are often cemented, such as below the sterntube in the after-peak tank. It is necessary for concrete ships to provide a coating on all surfaces of the oil tanks to prevent oil from seeping through. Mr. R. J. Wig, in a very interesting paper read before the Society of Naval Architects and Marine Engineers, November, 1919, stated that the interiors of all oil compartments were painted with two coats of magnesium fluosilicate and three coats of spar varnish, cheese cloth being placed between each successive layer of varnish. The above paper gave the following data about the 7,500-ton oil tankers building at Mobile: Main engine, 24½ inches by 41½ inches by 72 inches and 48 inches stroke, 2,800 indicated horsepower at 88 revolutions per minute; boilers, three oil-burning Foster watertube.

Regarding the size of heating coils for fuel oil tanks, cargo and bunker, ordinary steel ship practice should hold the following as being a common value; 1 square foot of heating surface to 60 cubic feet of oil, for double bottom and deep tanks less heating surface may be used.

Drilling holes for holding-down bolts after concrete has set and grouting same in is unsatisfactory; steel reinforcing may be encountered, and, furthermore, the process is slow. Mr. Wig advises that holes be drilled in fittings, etc., from templates by which the bolts were set in the forms. For stem, stern, and rudder construction as well as other information I would refer you to the following papers; "Concrete Shipbuilding in the United States," by W. A. Scott, Institution of Naval Architects, 1919; "Ferro Concrete Ship," by T. J. Gurette, North East Coast Institution of Engineers and Shipbuilders, 1918; also papers read before the Institution of Naval Architects in 1918, and articles published in the technical press of that year.

Thickness of Copper Piping

Q. (1,036).—Please let me know if the formulas:

$$\text{Thickness, } T = \frac{D.\,W.}{6{,}000} + 1/16'', \text{ for brazed copper pipe,}$$

$$\text{and } T = \frac{D.\,W.}{6{,}000} + 1/32'', \text{ for solid drawn copper pipe,}$$

where D is the diameter of pipe in inches and W is the working pressure in pounds per square inch, hold good for main steam, water and feed pipes for piping that must comply with Lloyd's regulations? Also give allowances necessary for pipes to be bent, and state if factor of safety is taken care of by the formulas.

A. (1036).—The rules which you have stated are those of the British Board of Trade (the United States Steamboat Inspection Service at present subscribes to the first rule for the thickness of copper pipe). The Board of Trade limits the size of solid drawn copper pipe, for which the second rule applies, to 10 inches, and also states that feed pipes are to be made sufficient for a pressure 20 percent in excess of the boiler pressure. Seaton and Rounthwaite's Pocketbook of Marine Engineering gives tables of copper piping for different pressures and purposes, which should be referred to. Both the above authorities give the working pressure for the pipe, not the ultimate, i. e., the factor of safety has been taken care of by the formula. Lloyd's Register of Shipping publishes no rule for the thickness of copper pipe, but accepts that of the Board of Trade.

Regarding bends, these should not be made sharp, in order to reduce the chance of weakness in outside of bend, and also to keep down the friction and dangerous effects of water hammer. The United States Steamboat Inspection laws consider a radius at the bend of 3/2 the pipe diameter as a minimum, this, of course, being far too sharp a bend for ordinary use. Where the pipe has to be bent it is necessary to allow for the thinning at the outside of the bend by ordering the pipe one or two gages heavier than that specified. This holds true for copper pipe which is bent, and also for large copper pipe the bends of which are made in two pieces. Care should be taken to allow for the thinning of pipe in bending both copper and steel, as inspectors very often measure the thickness at the outside of the bends, and will condemn pipe which falls below the required thickness.

The Bureau of Navigation, Department of Commerce, reports 112 sailing, steam, gas and unrigged vessels of 253,579 gross tons built in the United States and officially numbered during the month of January, 1920. Over 92 percent of the tonnage consists of steel steam vessels.

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Shipbuilding and General Marine News

Contracts for New Ships — Shipyard Improvements — Engineering Projects—Improved Appliances—Personal Items

SHIPPING BOARD GIVES UP OPERATING SHIPS

Private Concerns Will Handle Vessels Under an Agency Agreement and Make Their Own Rates

Operation of the Shipping Board fleet has been given up by the Board, which will allow private operators to handle the ships under an agency agreement. At present the Shipping Board operates certain vessels and private operators handle others. Henceforth private concerns will manage all the ships, retaining a percentage of the profits.

Coincident with this new policy, the Shipping Board has given up its authority over freight and passenger rates. Private operators will now be allowed to make the rates. Action of the Shipping Board was announced in this bulletin:

"Effective March 1, 1920, all Shipping Board tariffs, including current supplements thereto, are hereby canceled in so far as the public is concerned.

"Rates hereafter may be obtained direct from managing agents of shipping vessels."

The Government retains title to its ships, and the new operating policy is not in conflict with any general law for retention of the fleet.

Under the form of agency contract approved and in use, individuals, companies or corporations can operate the vessels on a profit-sharing plan. The Fleet Corporation reserves the right to terminate the agency at any time, and the agent can terminate his agreement on 30 days' notice.

For operating purposes the vessels are valued at $200 a deadweight ton, and profits are to be reckoned on this basis. Operating agents are permitted under the contract to retain 10 percent of all net profits up to 50 cents a ton a month. On net profits over 50 cents a ton a month, and not over $1 a ton, the agent retains 20 percent, and on all profits in excess of $1 a ton a month the agent gets 25 percent.

BUILDING CARGO SHIPS FOR FOREIGN ACCOUNT

Two Under Construction in Brooklyn for Montreal Concern

The keel of the first of two steel freighters contracted for by the Donald Steamship Company, Inc., of Montreal, was laid recently in the yard of the Tebo Yacht Basin Company, Brooklyn. These freighters are to be of 1,200 deadweight tons, 227 feet over-all length, 33 feet 8 inches beam and 16 feet depth. They will be oil-burning vessels with triple expansion engines of 1,400 indicated horsepower, and will have a speed of 14 knots, and while constructed for the transportation of fruit will have accommodations for a few passengers.

The Tebo Yacht Basin is the Eastern construction yard of the Todd Shipyards Corporation, 15 Whitehall street, New York, and it has made Brooklyn a shipbuilding as well as a ship repair center. The Tebo company has already delivered sixteen hulls, including nine mine sweepers and three oil tankers for the United States Navy, and is now completing a tanker for the Sinclair Navigation Company, 120 Broadway, New York.

ORDERS MORE TANKERS

Mexican Concern Adds Four to Its Fleet

The Eagle Oil Transport Company, Ltd., a subsidiary of the Mexican Eagle Oil Company, it is announced, has placed a contract with the Standard Shipbuilding Corporation, Shooters Island, N. Y., for four oil tank steamers of 8,400 deadweight tons each for delivery late this year. They will be used to carry crude oil from the Mexican Eagle's producing properties and in the oil trade between the United States and Europe.

The Transport Company's fleet at present aggregates more than 200,000 deadweight tons.

Converting Coal Burners

How rapidly the movement for the conversion of coal-burning steamers to oil is extending is indicated by the fact that during the past few months Messrs. Smith's Dock Company, of South Shields, England, has booked orders for the fitting of oil-burning installations on board no fewer than 59 vessels of an aggregate indicated horsepower of 193,010. Included among these are ten Anchor-Brocklebank liners and twelve Furness, Withy steamers.

INSURANCE FOR EMPLOYEES

Westinghouse Electric Plan Affects About 50,000 Employees

An insurance policy for $500 will be given, entirely without cost, to every employee of the Westinghouse Electric & Manufacturing Company who has been in the service of the company for a period of six months or more, according to a statement made by one of the officials of the company. The plan is effective March 1. In addition, the employees, after April 1, may increase the value of their policies for amounts varying from $1,000 to $2,000, depending upon their length of service and continuity of savings.

All employees who have been in the company's service for six months or longer, and who deposited a sum each payday in the Employees' Savings Fund, equal to 2 percent or more of their earnings, will not only receive 4½ percent interest compounded semi-annually on such deposits, but in addition will automatically have their insurance increased to amounts up to $2,000, depending on the length of time they have been with the company.

For example, a man who has been in the service of the company for at least fifteen years, and has regularly deposited in the Employees' Savings Fund 2 percent or more of his salary, on which he regularly receives 4½ percent compound interest, is presented with an insurance policy in one of the established companies for $2,000 at no cost whatever to him.

After an employee has maintained the required deposits for five years, he may discontinue, or withdraw his deposits from the Savings Fund without in any way affecting the value of his insurance policy. To provide for cases where employees need some money and do not wish to disturb their savings, loans will be made by the company to the extent of 90 percent of the amount to the credit of the employee in the Savings Fund without in any way affecting the value of the insurance.

This insurance is to be effective at all the offices and plants of the company, and will affect approximately 50,000 people.

National Marine Week stands for American Independence on the Sea.

Where Do You Stand?

National Marine Week Exposition, Grand Central Palace, Lexington avenue and Forty-sixth street, New York,

April 12-17, 1920

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SIX TANKERS ORDERED FROM NORTHWEST STEEL COMPANY

They Replace Cargo Ship Contracts Cancelled—Conversion of Japanese Built Ships Halted in Pacific Yards

Six steel tankers, of about 10,000 deadweight tons, are to be built for the Emergency Fleet Corporation by the Northwest Steel Company, of Portland, Ore. This announcement confirms the statement printed in SHIPS AND SHIPPING on February 27, which said that a big contract was going to the company.

Originally the Emergency Fleet Corporation planned to build six freighters at the Portland yard of the Northwest Steel Company, but, in view of the anticipated shortage of tonnage to move fuel oil to the various stations, which have been projected by the Shipping Board, it was decided that additional tankers were needed. Hence it was argued that the Northwest Steel Company should build tankers instead of freighters.

While more than a half million gross tons of tankers are building for private interests in American shipyards, the Government has fifty-two oil carriers of a total deadweight capacity of 498,675 tons on the ways or contracted for. The Government has a fleet of forty-eight tank steamers in operation at the present time.

When the Government embraced an oil-burning programme the outlook was more favorable than it is now. It was not anticipated that the large petroleum producers would be unable to fill the requirements of the Shipping Board at a reasonably low figure. One of the results of the failure to contract for the 1920 oil requirements has been the decision of the Shipping Board not to convert all of the freighters which it had built by Japanese and Chinese shipbuilding yards.

More than half the ships ordered from builders in the Far East have been launched and a number of deliveries have been effected. The first group of the Japanese ships was immediately turned over to the repair yards on the Pacific for conversion into oil burners. However, when it developed that there would be difficulty in obtaining fuel oil for the fleet the Emergency Fleet Corporation issued instructions that the other freighters should remain on a coal-burning basis.

The demand for tankers continues in spite of the fact that private interests have recently placed contracts for a vast number of oil carriers. It is reported that one prominent firm of naval constructors is preparing plans for a fleet of eight ships, bids for which will be asked from builders within the next few days.

MARINE WEEK PLANS

Revised Programme for the Celebration—Navy to Have Exhibit

A revised programme for the observance of National Marine Week, at the Grand Central Palace, Lexington avenue and Forty-seventh street, New York, is announced by the National Marine League, 268 Pearl street, as follows:

Monday, April 12—1 P. M. Inaugural luncheon aboard an American ship in New York Harbor, at which the ceremonies of the week will be opened formally by the Secretary of Commerce and the Chairman of the Shipping Board.

4 P. M. Formal opening of the National Marine Exposition by the Chairman of the Shipping Board at a private viewing, Grand Central Palace.

8 P. M. Shipbuilding Night at the Exposition.

Tuesday, April 13—7 P. M. Annual dinner of the National Marine League, Commodore Hotel, New York. Speakers will include the Secretary of the Interior and the Chairman of the Shipping Board.

Wednesday, April 14—8 P. M. Engineering Night. Special lectures and motion pictures at the Exposition.

Thursday, April 15—8 P. M. Travel Night. "Travel in American Ships" featured as a slogan at dinner, and celebrated under the auspices of the Travelers Club of America.

Friday, April 16—8 P. M. Fuel Night. Special lectures and motion pictures at the Exposition.

Saturday, April 17—8 P. M. Merchant Mariners' Night. Special films and features to stimulate recruiting of Americans for the merchant marine service.

The Navy Department is the third Federal branch to announce its participation in National Marine Week. Following orders issued by Secretary Daniels, the Navy is preparing an elabroate and unusually interesting exhibit, featuring naval appurtenances never before on view to the public.

The other two Government departments which will take part are the Shipping Board and the Department of Commerce, which will be represented by exhibits of the Bureaus of Navigation, Lighthouses, Steamboat Inspection and Fisheries.

The celebration of Fuel Day has been placed in the hands of a committee of the prominent coal and oil men, headed by F. S. Staley, president of the Fuel Oil Engineers Association. The other members include: H. C. Matlack, of the Matlack Coal and Iron Company; C. C. Smith, assistant general secretary of the American Petroleum Institute; Lindon C. Bates, consulting engineer, and Frank Shipman, of the Texas Company.

A committee to take charge of Engineers' Day was also formed at a recent luncheon meeting. It is composed of H. L. Aldrich, chairman; Capt. C. A. McAllister, secretary of the Shipping Board committee to revise navigation laws; and Walter MacFarland, authority and writer on marine engineering. William T. Donnelly, naval architect and marine engineer, will be one of the speakers.

PREPARING FOR BUSINESS

Anglo-American Oil Investing Heavily in Depots and Bunker Stations

Word comes from London that the Anglo-American Oil Company is building factories, filling stations and depots at various places, such as Avonmouth, Newport, the Manchester Ship Canal and Brilham, also on the Clyde and Humber, at an expenditure of several millions of pounds.

This work represents arrears of progress arrested by the war, and also involves provision for the increasing demand for oil products, notably for purposes of steamer bunkering.

The Scottish-American Oil Company, formed last November, is also understood to be negotiating for the control of the Trinidad Central Company, owning concessions of the 70,000 acres in the island of Trinidad.

New Practical Safety Device

Emery wheels, rotary cutting machines, etc., are a constant source of danger to the workman's eyes. With "safety first" being preached by trained organizations of safety men in all big industrial establishments, any device designed to protect the worker's eyes from injury is of general interest. Goggles and glass shields have proven fairly satisfactory, but not entirely so because of the liability of the glass to become broken. Recently safety glass and transparent sheeting (the same material used for lights in auto curtains) have been tried with great success. The safety glass is made either by laying it in a coarse mesh of fine wire, or by employing hydraulic pressure to weld a piece of the transparent sheeting between two sheets of glass.

However, for goggles or shields over emery wheels the transparent sheeting alone is very effective. It is cheaper and lighter than any form of glass. Fire glass (having the wire in it), safety glass or the transparent sheeting alone can be fitted in an oblong frame to be imposed over the wheel in such a position as to deflect emery dust and metal particles away from the operator's eyes.

The fire glass is not suitable for goggles, but the safety glass or the sheeting alone is all right for the purpose.

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AMERICAN RED CROSS PLANS TO HELP AMERICAN SAILORS

Bureau of Marine Service Will Be Operated By Seaport Chapters—Needed In the Far East

A special service for the boys who man our merchant ships has been inaugurated by the American Red Cross in the new Bureau of Marine Service. This work will be carried on by the seaport chapters of the American Red Cross all over the world.

A reading and writing room to which sailors may repair for rest and recreation, and which they may use as their headquarters while in port, has been urged on Red Cross chapters as the solution of a long-felt need for American sailors in foreign cities. A chapter member will act as hostess to look after the comfort of the transient guests.

Some cities already have a seamen's home, and in these places the Red Cross will co-operate with this existing agency and supplement its service.

American shipping has increased enormously. More and more seamen are needed to meet the after-war demands of trade expansion. The United States Shipping Board is endeavoring to meet this situation by raising the standard of the seaman's calling, so that a fine type of young American may be persuaded to enlist.

"It will fill a big need in the Orient," said Julian Arnold, a former Red Cross division field representative in China, when told of the new Bureau of Marine Service. "There are no provisions in such ports as Shanghai, Hongkong or Manila for entertainment of a wholesome nature for the American sailor. He is expected to be an outcast and to associate with the dregs of humanity. And how many self-respecting men can be expected under these conditions to choose to follow the sea?

"If America is to build up her merchant marine in a way which will be a permanent asset, careful consideration must be given to its personnel. This means improved conditions for the men that man the ships. Accommodations should be provided in every port which will permit the sailor to have wholesome entertainment under decent auspices. There should be an American reading room where newspapers, writing material, etc., are supplied. There should also be recreational facilities as provided by any club."

This work, Mr. Arnold feels, will be enthusiastically welcomed by American Red Cross members in these seaport cities.

"In Shanghai," he said, "there is an American population of 2,000, who are under the protection and laws of the United States and are not subject to the laws of China. It therefore would be an easy matter to carry on this work under American auspices. Since Americans there are enthusiastic over all outdoor sports—football, baseball, rowing, tennis, etc.—it would not be difficult to provide facilities by which the American sailors might participate

OIL AT $1.34 TO $2.07

Shipping Board Buys 11,000,000 Barrels

Fuel oil contracts covering a total of 11,000,000 barrels, at prices ranging from $1.34 to $2.07 a barrel, have been placed by the Shipping Board for the six months' period beginning April 1.

The contracts were made with the Mexican Petroleum Corporation, 120 Broadway; the Atlantic Gulf Oil Corporation, 11 Broadway, and the Standard Oil Company of New Jersey, 26 Broadway, New York, and cover deliveries at various Atlantic ports between New York and Galveston.

Morgan Firm Represented in Submarine Boat Directorate

Henry R. Carse, president of the Submarine Boat Corporation, 5 Nassau street, stated to the directors at the annual meeting a few days ago that the company had plans for the construction of a fabricated vessel of larger dimensions than the present 5,350-ton ship.

Perhaps the most important development was the election of Thomas Cochran, of the firm of J. P. Morgan & Company, to the board of directors. This was thought to be quite significant, as indicating the entrance of Morgan money into shipbuilding operations.

Westinghouse to Enlarge Its Turbine Plant

The Westinghouse Electric & Manufacturing Company, 165 Broadway, New York, announces that it has awarded to the Westinghouse, Church, Kerr Company, 37 Wall street, New York, the contract to erect four new buildings at its South Philadelphia plant, Lester, Pa., which is devoted to the manufacture of land and marine turbines. These new buildings, which will be of terra cotta and steel, will be of the highest grade of construction throughout, and will consist of a shop for building small turbines, a new machine shop, an addition to the erecting shop, and a new warehouse.

National Marine Week stands for American Independence on the Sea.

Where Do You Stand?

MARINE OIL ENGINES IN INDIA

American Machinery Being Used in Large Vessels

An increasing market for marine oil engines in India is noted in the English publication *Commerce*, which says that numbers of moderate-sized wooden motor vessels are now being built in that country for coastal and overseas trade.

An interesting example of this development is shown in the auxiliary barque *Ajrabia Khatoon*, which is built of wood entirely by native labor. She is 130 feet in length, with a beam of 30 feet and a depth of 20 feet, the fuel tanks having a capacity of 3,000 gallons. The machinery installation comprises two 100 brake-horsepower Fairbanks-Morse hot-bulb oil engines, while in addition there is an electric lighting set and two motor hoists, all driven by Fairbanks-Morse engines. The installation was carried out by Pyne, Hughman & Company, of Calcutta.

Reuter reports that among other motor vessels under construction in India are several of 1,000 to 1,500 tons, equipped with hot-bulb oil engines of British or American manufacture.

Rubel Brothers' Refrigerating Concern

The refrigerating plant of Rubel Brothers, East New York, is a typical example of the high efficiency attained by the modern ice-producing plant. Completed in the early part of 1919, production has been practically continuous throughout the season, and an average output of some 240 tons of ice per day is recorded.

The closed type 14 by 16-inch ammonia compressors, belt driven from two 175-horsepower Westinghouse motors, are the principal compressors, but two 25-ton compressors operated by 50-horsepower Westinghouse motors are also installed as supplementary machines. Air compressor duty is performed by three compressors, operated by 30-horsepower Westinghouse motors. Central station power, furnished by the Brooklyn Edison Company, is used, and motors are AC type. There are two refrigerating rooms, one on the ground floor and one on the first floor, in which some 3,020 cans are housed, with necessary brine agitating equipment. The latter is driven by eight Westinghouse 3-horsepower motors.

Well water is used from artesian wells sunk upon the premises, and pumped by three 20-horsepower Westinghouse motor operated pumps. Two water pumps, driven by three and five-horsepower motors, are used for circulating purposes. Storage space is afforded for 100,000 cakes of ice, which are transported from the refrigerating rooms to the storage room by means of three elevators operated by Westinghouse 5-horsepower motors.

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Marine Construction News of the Month

Ship Contracts—New Ship Concerns and Shipyard Improvements—Terminal Projects—Government Contracts

SHIP CONTRACTS

The Kruse & Banks Shipyards, Coos Bay, Oregon, has laid a keel for a steam schooner for private interests.

Tankers, Portland, Ore.—Six steel tankers of about 10,000 deadweight tons will be built for the Emergency Fleet Corporation by the Northwest Steel Company.

Motor Launch, Staten Island.—The Staten Island Shipbuilding Company has been awarded a contract for a steel motor launch for the Standard Oil Company of New York.

Tankers, Harriman, Pa.—It is announced that the Merchant Shipbuilding Corporation has taken a contract to construct six steel tankers of 12,000 tons each, at a total cost of about $11,250,000.

Fruiters, New York.—It is reported that the Atlantic Fruit Company, 61 Broadway, is seeking bids for the construction of vessels of about 2,500 to 3,000 deadweight tons, for use in its fruit trade.

Steel Hull, Washington, D. C.—The United States Engineer's Office War Department is having specifications made for a steel hull to replace the wooden one of the U. S. dredge Grosselete.

Barges, Florence, Ala.—The United States Engineer's Office, War Department, Washington, has let contract for building ten barges for Wilson Dam to the Murnan Shipbuilding Corporation, Mobile. Price, $7,468.

Tankers, Boston, Mass.—The Cochrane-Harper interests of Boston have placed contracts with the Merchant Shipbuilding Corporation, 165 Broadway, New York, for two 10,000-ton tankers of 10½ knots' speed.

Steel Hull, Nashville, Tenn.—The United States Engineer Office, 4th and 1st National Bank Building, let contract for building a steel derrick boat hull to the Howard Ship Yard & Dock Company, Jeffersonville, Ind. $14,973.

Steel Barges, Vicksburg, Miss.—United States Engineer Office, Third Mississippi River District, P. O. Box 404, will receive sealed proposals until 11 o'clock, April 10, for constructing three steel barges. Information on application.

Not a Subsidiary.—The Saginaw Shipbuilding Company, Saginaw, Mich., referring to an item in March Marine Engineering, wishes announcement made that it is not a subsidiary of the American Shipbuilding Company of Cleveland, Ohio.

Tanker, Chester, Pa.—The Department of Commerce reports that an 8,000 gross ton oil tanker will be built by the Sun Shipbuilding Company, of Chester, Pa., for the Société Anonyme D'Armement, D'Industrie, et de Commerce, a French organization.

Changing Steamship, Jacksonville, Fla.—The Merrill-Stevens Shipbuilding Corporation has contract for changing the steamer Otsego, formerly the Prince Eitel Frederick. She will be made a passenger ship of the highest grade and her machinery will be completely overhauled. Contract price, $1,000,000.

Steel Catamarans, New York.—United States Engineer Office, War Department, Washington, D. C., let contract for steel catamarans for dredging in San Juan Harbor, Porto Rico, to Greenlie Halliday Company, 499 Water street. About $46,000.

Complete Wooden Hulls, Portland, Ore.—The Monarch Shipbuilding Company will complete two wooden hulls now on the ways of the Grant Smith-Porter Shipbuilding Company. One will be made a sailing schooner, but plans for the other have not been completed.

Tankers, Staten Island, N. Y.—The Standard Shipbuilding Corporation, Shooters Island, has received contract for four tank steamers of 8,400 tons deadweight, for delivery late this year, from the Eagle Oil Transport Company, a subsidiary of the Mexican Eagle Oil Company.

Steamers, Lorain, Ohio.—The American Shipbuilding Company, of Cleveland, will build four steamers of 12,000 tons each on its own account at the company's Lorain yards. The ships will be 600 feet long, 60 feet beam, and 32 feet deep. They will be completed this year and will have every modern improvement.

Schooners, Portland, Me.—The Russell Shipbuilding Company is gathering materials for two four-masted schooners of 1,300 tons each, the vessels to be afloat in October. The Cumberland Shipbuilding Company will launch a four-masted 1,000-ton schooner late in May and build another larger one immediately after.

Freighters, Chester, Pa.—The American-Hawaiian Steamship Company, 8 Bridge Street, New York, have placed an order for two 11,000-ton shelter deck freighters with the Merchant Shipbuilding Corporation. They will be equipped with Burmeister and Wain Diesel engines from the works of the Cramp Company, Philadelphia. A speed of 11 knots is calculated on.

Coast Guard Cutters, Seattle, Wash.—The Seattle North Pacific Shipbuilding Company has submitted the lowest bids for building five steel coast guard cutters, the original contract for which had been awarded to the Norway Pacific Shipbuilding Company, of Everett, Wash. The bid was a flat price of $689,000 for each ship.

Building to Continue, New Orleans.—The New Orleans shipyard of the Foundation Company, 233 Broadway, New York, is to continue operation after the completion of the company's contract with the French Government for building steamships of the non-sinkable Le Parmentier type, the last two of which are to be launched this month. Announcement was made by Mr. H. D. Bacon, manager of the New Orleans plant.

Tankers, Chester, Pa.—Two 12,500-ton tankers have been ordered by the Union Oil Company of Delaware, 120 Broadway, New York, to be delivered in March, 1921, by the Sun Shipbuilding Company, of Chester, Pa. The same company has ordered from the Merchant Shipbuilding Corporation, 165 Broadway, New York, two tankers of 10,500 tons each, to be delivered in November and December, 1920. These will be built at the Chester yards.

Converting Training Ship, San Francisco, Cal.—The training ship Iris of the Sea Training Bureau of the Shipping Board is to be converted into a combination freighter and training vessel, according to Henry Avila, San Francisco chief of the service. The sleeping quarters will be reduced, and the vessel put into a regular freight-carrying service, which will give apprentices more practical training and make the service nearly self-supporting.

Freighters, Brooklyn.—The Tebo Yacht Basin Company, Brooklyn, has laid the keel for the first of two steel freighters for the Donald Steamship Company, Inc., of Montreal. They are to be 227 feet over all, 33 feet 8 inches beam, and 16 feet deep, oil burners, with triple-expansion engines of 1,400 indicated horsepower, and a speed of 14 knots. The Tebo concern is the eastern construction yard of the Todd Shipyards Corporation, 15 Whitehall street, New York.

Wooden Tankers, Seattle.—Five of the wooden hulls tied up in Lake Union, Seattle, have been bought by A. A. Daugherty, of the National Shipbuilding Company, 1608 Woolworth Building, New York City, and are to be converted into tankers carrying from 35,000 to 40,000 barrels of oil each. No steel will be used except for the caisson around the engine room, the tanks being of wood and fashioned of bulkheads. The cost of the hulls with their machinery and equipment was $775,000. J. H. Price Construction Company will do the work at the Meacham & Babcock plant.

PORT IMPROVEMENTS

Marine Railways, Oakland, Cal.—The Moore Shipbuilding Company is to build two marine railways with a capacity of 6,600 tons each.

Sea Wall, Trenton, N. J.—The City Commission plans to build a 1,700-foot sea wall along Assanpink Creek. About $150,000. Address F. W. Donnelly, mayor.

Dry Dock, Alameda, Cal.—The Bethlehem Shipbuilding Corporation, Ltd., will soon begin the building of a 10,000-ton floating dry dock, according to recent announcement.

Bulkhead, Astoria, Ore.—Sanitary Reclamation Committee plans to issue $200,000 bonds to build bulkheads for reclamation work along waterfront. G. T. McClean is engineer.

Wharf, Etc., Sitka, Alaska—Spec. 4151.—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build at Jafronski Island, involving an expenditure of about $16,000.

Dredging, Detroit, Mich.—The United States Engineer Office will receive sealed proposals until 11 A. M., April 15, 1920, for dredging at Rouge River, Mich. Further information on request.

Channel, New York.—The United States Engineer Office, 39 Whitehall street, will submit specifications for channel, 20 feet deep, 300 feet wide, up to Nairn Linoleum Works at Kearney, N. J.

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Dredging, New Jersey.—The United States Engineer Office, 39 Whitehall street, New York, will have specifications made for maintenance dredging in Keyport Harbor, N. J.; also in Shrewsbury River, N. J.

Breakwater, Cleveland, N. Y.—E. S. Walsh, Superintendent Department of Public Works, Albany, N. Y., let contract protecting breakwater at Cleveland Terminal. Contract 28-A to E. Dawley, Cleveland, $13,260.

Piers, Baltimore, Md.—The Terminal Warehouse Company, Davis and Pleasant streets, will construct two piers and warehouse, 575 by 150 feet and 583 by 150 feet; waterway 200 feet wide between.

Breakwater, Crescent City, Cal.—Government engineers have approved a contract for building a $200,000 breakwater, a third of a mile long. DeNorte County will then be opened to settlement and industry.

Terminal, Cairo, Ill.—The city has recently purchased from a private company, which owned the waterfront, all their right and title to same, and will erect a terminal suitable for the needs of that locality.

Breakwater, Milwaukee.—The Sewerage Commission let contract for building pile and timber breakwater at east side of Jones Island, to Great Lakes Dredging & Dock Company, West Water street. $275,930.

Steel Sheet Piling, Louisville, Ky.—The United States Engineer Office will receive proposals for furnishing and delivering steel sheet piling for Lock No. 44, Ohio River, until April 9, 1920. Information on request.

Lock, Allegheny River, Pittsburgh, Pa.—The United States Engineer Office will receive sealed proposals for constructing Lock No. 5, Allegheny River, near Schenley, Pa., until noon, April 16, 1920. Information on request.

Dock, Milwaukee, Wis.—The Chicago, Racine & Milwaukee Line, Broadway and Erie avenues, are having plans prepared for a 400-foot reinforced concrete and pile dock. A. E. Hecht, 64 West Randolph street, Chicago, is engineer.

Dredging, Long Beach, Cal.—Belmont Pier Tract Company let contract for dredging 700,000 cubic yards from Alamits Bay and filling old canal and lowlands to United Dredging Company, Central Building, Los Angeles, $0.144 per yard.

Jetty Construction and Repairs, Wilmington, Del.—The United States Engineer Office will receive sealed bids for jetty construction and repairs at the mouth of the Mispillion River, Delaware, until 11 A. M., April 5. Further information on request.

Dredging and Repairing Breakwaters, Milwaukee, Wis.—The United States Engineer's Office, Federal Building, has approved specifications for dredging, repairing and riprapping 1,000 feet south breakwater in Ludington Harbor. Cost, $110,788.

Grain Elevator, Canton, Md.—Five ships can be accommodated at one time at the new grain elevator of the Pennsylvania Railroad Company put into operation recently, and which has a capacity of 4,257,000 bushels. Cars are unloaded by the tilting plan.

Dredging, Mobile, Ala.—Dredging the Mobile River near the Eslava street dock of the Alabama Dry Dock & Shipbuilding Company to a depth of 18 feet was started recently. When completed, the work will give a large amount of additional dock room.

Dry Dock, Vancouver, Wash.—Plans have been filed by representatives of David Rodgers, of Seattle, for a dry dock at Vancouver, Wash., which, if accepted, will probably be followed by the investment of $15,000,000 of British capital in the Burrard Inlet.

Concrete and Steel Shop, Quincy, Mass.—Bethlehem Shipbuilding Corporation, Ltd., soon will let contract for building a three-story 50 by 220-foot concrete and steel shop, reinforced concrete flooring, concrete foundation, at Fore River. About $75,000. Private plans.

Steamer Dock, Vancouver, Wash.—The city is having plans prepared for building first unit of new steamer dock, 964 feet frontage, concrete and steel, with frame wood piling, including 100 by 500-foot warehouse. About $130,000. A. C. Shumway, Vancouver, engineer.

Wharf, Etc., Astoria, Ore.—G. W. Sandborn Company let contract for building 500-foot wharf, 125-foot railway extension from railroad to pier headline, two 50 by 100-foot slips, 40 by 75-foot pier and warehouse to Gilpin Construction Company, Astoria. About $70,000.

Dredging, Providence, R. I.—Sealed proposals for dredging in Connecticut River below Hartford, Conn., will be received here until 2 o'clock P. M., April 1, 1920, by the United States Engineer Office, Providence, R. I., and then opened. Information on application.

Rock for Lighthouses, Sand Island, Ala.—Sealed proposals will be opened by the Superintendent of Lighthouses, New Orleans, Ala., 2 P. M., April 8, 1920, for furnishing and placing 1,800 tons of rock around Sand Island Lighthouse, Ala. Information upon application.

Extending Plant, Chester, Pa.—The Sun Shipbuilding Company plans a 600-foot dry dock, also a wet dock 600 feet by 200, with additional ways and shops. Ships up to 20,000 tons may be handled on the new ways. The improvements are expected to cost about $3,000,000.

Removing Wreck, Hudson River, New York.—United States Engineer Office, 39 Whitehall street, let contract for removing wreck of schooner May E. Lynch in Hudson River Channel, 1st District, to Merritt & Chapman Towing & Wrecking Company, 17 Battery Place, New York.

Terminal, Peoria, Ill.—Plans have been prepared by the City Engineers for a terminal consisting of either a dock parallel with the river and extending out into the lake, or two piers similar to those used at ocean terminals extending out into the bay. A temporary dock is being used.

Radio Plant, Seattle, Wash.—By the installation of a radio plant on the outer end of Pier 1, vessels anchored in the bay will be afforded free communication with others by wireless. This is said to be the only plant in the United States installed for the accommodation of vessels anchored in a port.

Machine Shop, Wharves, Docks, Etc., Norfolk, Va.—The Norfolk Shipbuilding & Dry Dock Corporation, 494-526 Argyle avenue, plans to construct seven or eight buildings, machine shop, also wharves, docks etc., involving cost of over $100,000. Neubauer & Supourtz, 929 Chestnut street, Philadelphia, engineers.

Removing Island, Houston, Tex.—An island in the Houston Ship Channel, opposite Deepwater, below the turning basin, is to be removed, according to plans by which the island has been made available for removal by the Government. A second turning basin will be dredged at the island, it has been announced.

Dry Dock and Oil Station, Wilmington, N. C.—With progress in deepening the channel of the Cape Fear River between Wilmington and Southport, efforts of Wilmington shipping men to secure a modern dry dock, fuel station and a sub-coaling station for the port have been redoubled and are likely to succeed.

Dredging, Wilmington, Del.—Work on the improvement of the Chesapeake and Delaware Canal will probably be started this summer, according to Lieut.-Col. J. P. Jervey, who has been asked to submit a program showing the order to which the various parts of the work should be executed. Dredging on the river will be started April 1.

Wharf, Etc., and Dredging, City of Everett, Mass.—Application for permission to build a pile wharf and dolphins and to dredge in Mystic River has been made to the State Department of Public Works, Division of Public Lands, by the Beacon Oil Company. Plans outlining the proposed work have been filed at the office of the department.

Fuel Oil Terminal, Seattle, Wash.—The General Petroleum Company's new fuel oil terminal on Harbor Island became a factor in North Pacific commerce with the arrival of its first cargo of 65,000 barrels of oil on the tanker Devolente. It occupies a large site at the north end of Harbor Island, and is enclosed by a 16-foot concrete wall.

Harbor Improvements, Tokyo.—The Japanese Consul at Washington announces that his government is to make Tokyo a big seaport and will spend 350,000,000 yen in the next ten years in extensive dredging operations and the construction of breakwaters. This will obviate the necessity of ships having to go to Yokohama, eighteen miles distant.

Rat-Proofing, New Orleans, La.—Dr. M. S. Lombard, of the United States Public Health Service, served notice on the commercial interests of New Orleans that unless the dock board, railroads and other interests speeded up the work of rat-proofing at least one wharf and one railroad terminal a month, the Government would be obliged to quarantine the port.

Port Improvement, Wilmington, Del.—It is announced that the bulkhead type of construction will be provided for in the decision of the Board of Harbor Commissioners for the $3,000,000 port project on the Lobdell tract. The location of the property at the junction of the Christiana and Delaware rivers makes this type of harbor the only feasible one for the site.

Developing Waterfront Terminals, Providence, R. I.—Edward G. Buckland, president of the New Haven Railroad, urges the development of transportation in Providence mainly between Kettle Point and Gaspee Point or Conimicut, and that New Haven should develop its waterfront terminals and co-ordinate them more thoroughly with its rail lines and freight yards.

Dredging, Wauna, Ore.—A communication received by the Port of Astoria Commission from the Crossett Western Lumber Company asks that dredging be done in front of the plant at Wauna. They want the cutting of a waterway between two deep pockets, a distance of 3,000 feet, 300 feet wide and five feet deep. The commission agreed to do this dredging as soon as present projects are completed.

Freight Sheds and Piers, Stapleton, S. I., New York.—Murray Hulbert, Commissioner of Docks, Pier A, North River, N. Y., let contract for building new freight sheds and appurtenances on Piers 6, 7, 8, 9, 10 and 11 to Bethlehem Steel Bridge Corporation, 111 Broadway, New York. $2,577,950. Also let contract for furnishing labor and material for building Piers 6, 7, 8, 9, 10 and 11 to Terry & Tench, Grand Central Terminal, New York. $3,252,570.

Dredging, Seattle, Wash.—A plan to dredge a ship waterway from the north end of Lake Washington to Bothell, a distance of 2½ miles, at an estimated cost of $1,750,650, was submitted by Port Engineer George F. Nicholson to the Seattle Port Commission for consideration. The proposed waterway would be 300 feet wide and 20 feet deep at extreme low water. At the narrowest part of the valley the width would be reduced to 200 feet and widened to a width of 250 feet at Bothell.

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Improving Waterfront and Deepening Channel, Tampa, Fla.—Plans for Tampa's municipal waterfront have been ordered by the Board of Port Commissioners, and an engineer has been employed to supervise the carrying out of the plans when they have been accepted. Dredging work on the 27-foot channels in Tampa Bay is progressing, three miles having been completed and work begun on another section. The United States Dredging Company will begin its contract work in May, and the entire project should be completed in 1921.

Channels, Jamaica Bay, New York.—The deepening of Jamaica Bay Channel up to Mill Basin to a depth of 30 feet, which is part of the New York-New Jersey Harbor Development Commission plan, has been approved by the War Department. This approval carries the proviso that no work should be done and no expenditures made until plans satisfactory to the chief of engineers and Secretary of War have been submitted, with evidence that the city of New York or some other trustworthy agent will build suitable wharves and equipment. The matter is largely in the hands of Murray Hulbert, Commissioner of Docks and Director of the Port, Pier A, North River.

Piers and Dry Dock, Manila, P. I.—A fourth pier approximately 1,000 feet long and 240 feet wide is being completed early this year and a fifth pier is under construction, on which construction will probably begin at an early date. A marginal wharf 1,000 feet long has been constructed and its length is likely to be tripled within the next year. Two Government wharves will be extended and enlarged, and it is planned to pipe each pier, to enable oil-burning vessels to receive fuel as soon as they are tied up. The new piers will be equipped with every modern improvement. The anchorage depth will be dredged to a depth of 40 feet. A dry dock of the latest model will be constructed. It will be between 600 and 700 feet long and capable of caring for ships of 20,000 to 25,000 tons.

Port Improvement, Milwaukee, Wis.—Plans for improvement of the lake front at Milwaukee include pile revetment at Jones Island, contract for which has been awarded, dredging Kinnickinnic Basin, building rubble mound breakwater from Wisconsin street to the harbor entrance, 5,000 feet, six piers each 700 feet long and 300 feet wide, with slips 250 feet wide, a pier 100 feet wide, a slip for car ferry steamers, a breakwater 5,000 feet long, 700 feet from the shore south of the sewerage disposal plant space to be filled in, a cement dock on the inner side of Jones Island and other work. The docks will carry double railroad tracks, and viaducts will lead from freight sheds over the yards to the city streets. Sheds and warehouses of steel and concrete. The improvements will add fourteen miles to Milwaukee's waterfront, and the cost is estimated at $15,000,000. H. McL. Harding, 52 Vanderbilt avenue, New York, consulting engineer.

Piers, Dredging, Etc., Pearl Harbor, T. H.—The Hawaiian Territorial Government has plans under way covering the triple piers 8, 9 and 10, giving cargo space of approximately 360,000 square feet. The Harbor Board will complete this year a new pier on the site of the old channel wharf, and the dredging of the Kewalo Bay for a wharf. Extensive area off Fort and Allen streets has been acquired by the Territory and will be transformed into a continuation of Pier 10. The harbor will be widened between Pier 9 and the old quarantine wharf on Sand Island, by dredging the concrete posts and coral on the quarantine side. The eastern end of the harbor will be developed by elaborate plans adopted by the Inter-Island Steam Navigation Company. The Naval Board has recommended the expenditure of $27,000,000 at the Pearl Harbor Naval Station, in addition to large sums of contracts now under way.

SHIPBUILDING AND REPAIR PLANTS

Shipyard, Galveston, Tex.—Sudermann & Young plan marine ways, etc., at Galveston; capital, $20,000.

Repair Plant, Texas City, Tex.—The Gulf Marine Repair Works has been organized to repair vessels without interference with loading.

Dry Dock, Savannah, Ga.—The Rourke Dry Docks Company has been incorporated with $50,000 capital by John, James A. and John Z. Rourke.

Shipbuilding Plant, St. Andrews, Fla.—The St. Andrews Bay Ways Company has been organied. A 200-foot cradle and shipways are planned.

Repair Plant, Houston, Tex.—The Bedman Machine Company has closed contract with the city of Houston for operating a ship repair plant at Municipal Dock No. 1.

Dry Dock, New London, Conn.—A commission has been appointed by the mayor of New London in the matter of a dry dock and to secure data as to the cost of dredging, etc.

Resuming Work, Kewaunee, Wis.—Work on the new yards of the Wisconsin Shipbuilding & Navigation Company has been resumed and is going ahead rapidly. It was delayed by lack of railway cars.

To Sell Plant, Portland, Me.—The Cumberland Shipbuilding Company's installation plant is offered for sale by the United States Shipping Board. The plant includes about 15 acres of land, wharf and various buildings.

Would Buy Shipyard, Seattle, Wash.—An offer of $3,400,000 has been made to the Shipping Board by David Rodgers for the Skinner & Eddy shipyard No. 2 at Seattle. The Government purchased the yard two years ago for $3,874,000.

Steel Plant, Houston, Tex.—The site for a steel plant on the Houston Ship Channel has been bought by the Lone Star Bridge & Steel Works, George E. Coles, president. A marine repair shop will be operated in connection with the plant.

New Shipyard, Norfolk, Va.—The Norfolk Shipyards Company, capital $500,000, president Benjamin Lowenberg, plans building a marine railway, machine shop, foundry, woodworking shop and ways for concrete barges. The site comprises 50 acres.

Shipyard Merger, Providence, R. I.—The Lord Dry Dock Company, a combination of the Lord Construction Company and the Marine Engineering & Dry Dock Company, of Providence, has been incorporated under the laws of Delaware, with a capitalization of $20,000,000.

Marine Railway, Chelsea, Mass.—The last unit of the equipment of the Winnisimmet Shipyard, Chelsea, has recently been completed. The power house is not yet finished. The way is 680 feet long, 70 feet wide, and will cost about $750,000.

Sell Concrete Shipyard, Wilmington, N. C.—The Emergency Fleet Corporation is offering for sale the Liberty shipyard, consisting of 42 acres of land, with a river frontage of 1,600 feet. Bids will be received up to noon, April 7, 1920. The cost of the plant was approximately $800,000.

To Sell Plant, New London, Conn.—Frederick Conlin and P. LeRoy Harwood, receivers of the Groton Iron Works, formerly controlled by the Morse interests, 50 Broad street, New York, have made application to the Superior Court for permission to sell the plants in Groton and Noank.

Dry Dock, San Pedro, Cal.—The first pontoon for the dry dock for the Los Angeles Shipbuilding & Dry Dock Company has been towed to its place, and work on the other pontoons is rapid. The new dock will accommodate vessels up to 10,000 tons and will cost $1,000,000 when completed.

Dry Dock, Wilmington, N. C.—Foundations have been laid for the new pipe and cover shops at the Carolina Shipyard, a part of the shipyard repair plant now in course of construction. In addition to the repair plant, a concrete dry dock to accommodate ships up to 7,500 deadweight tons may be built, at an estimated cost of around $1,000,000.

Building and Repair Plant, Knoxville, Tenn.—The Knoxville Ways Company, recently organized, will take over one of the old boat-building yards on the Tennessee River near 14th street. A power plant will be installed, with three cradles of sufficient size to accommodate any steamer on the rivers. Timber will be obtained from local lumber mills, but other materials will be purchased in open market. Captain John Harris, H. C. Milnor and Malcolm McDermott are interested in the enterprise.

SHIPPING DEVELOPMENTS

New Steamship Service, Boston, Mass.—The New England Maritime Corporation has established a steamer service between Boston and San Francisco, via the Panama Canal.

Clyde Line Enlarges Fleet, New York.—Two steamers, the Lake Fernaldo and Lake Reo, have been added to the fleet of the Clyde Line to operate between New York and Wilmington, Del.

Atlantic-Gulf Route, Baltimore, Md.—The Southern Pacific Steamship Company has applied to the Interstate Commerce Commission for permission to operate a line from Baltimore to Houston and Galveston.

New Steamship Line, Tampa, Fla.—M. E. Gillette & Son has recently been incorporated with a capital of $1,000,000. M. E. Gillette, president; D. C. Gillette, vice-president and treasurer, and George R. McKean, secretary.

Steel Steamer Purchased, Seattle, Wash.—The steel steamship Francis L. Skinner has been sold to the Oriental Navigation Company, 17 Battery Place, New York, by the Skinner syndicate for operation on Atlantic routes.

Steamers Purchased, Wilmington, Del.—Capt. Horace Wilson, of the Wilson Line, has purchased the steamers Favorite and Pokanoket. Wilmington interests intend to use these boats in connection with their line running in Florida waters.

New Steamship Company, Baltimore, Md.—The Atlantic-Gulf and Pacific Company, a transatlantic, transpacific and coast to coast steamship enterprise, with headquarters at Baltimore, has been filed with the Maryland State Tax Commission. Capital, $2,000,000.

Freighters Purchased, Seattle, Wash.—The Green Star Steamship Company has purchased the freighter Santa Cecelia, formerly owned by W. R. Grace & Company, bringing the total number of steel steamships owned by the company to eighteen.

Steamers Wanted, Seattle, Wash.—A. F. Haines, vice-president and general manager of the Pacific Steamship Company, has applied to the Shipping Board for the allocation of six new 17½-knot passenger steamers for operation from Puget Sound to the Orient.

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Coastwise Freight Line, New York.—A fortnightly freight service from New York to San Francisco was inaugurated on March 16 with the 5,350 deadweight ton Shipping Board steamer Delisle, flying the house flag of Williams, Dimond & Company, 8 Bridge street.

The Old Colony Shipping Corporation will be the Boston, Mass., agents of the Southern Transportation Company, of Baltimore, which has recently purchased a number of 2,500-ton barges from the Shipping Board, to be placed in the coal trade between Chesapeake Bay and New England ports.

Steamer Line Quits, Providence, R. I.—The Block Island, Newport and Providence Transportation Company went out of business when the steamer Juliette made her last trip to Block Island and Newport. The end of operations of the company comes primarily through the sudden deaths of Frank J. Gethro and Vincent Gethro.

New Shipping Company, Berkeley, Cal.—Extensive shipping facilities will be established on the Berkeley waterfront. With a capitalization of $250,000, the F. W. Stow Finance Company was incorporated to do shipping business by land and sea, charter vessels, build warehouses, etc. Officers are F. H. Stow, A. A. Sanders and E. B. Davies.

Steamship Company Obtains More Room, New York.—W. R. Grace & Company have purchased 84 and 86 Pearl street and 50 and 52 Water street, covering a plot of 5,600 square feet. The buyers hold title to the Grace Building at 3 and 13 Old Slip. With the property just purchased, frontage on Water street of 253 feet has been secured.

Proposed New Steamship Line, Philadelphia, Pa.—The Philadelphia Chamber of Commerce is negotiating with steamship men of Boston for a line of large steamships to sail from Boston and Philadelphia through the Panama Canal to Los Angeles, San Francisco and Seattle. Service contemplated at the outset is for three steamers of 8,500 to 10,000 tons each.

Trans-Oceanic Line, Baltimore, Md.—The Danzig-Baltimore Steamship Corporation proposes to sail a passenger and freight fleet between Baltimore and Danzig, pending the passing of the $50,000,000 authorization loan bill for harbor and pier improvements. The necessary capital has already been secured and eight ships flying the American flag will be put on the line.

Shipping Company Increases Capital, Portland, Ore.—C. M. Dant and Edward Christensen, of San Francisco, and a group of men headed by Emery & Olmstead, of Portland, have purchased the outstanding stock of the Columbia Shipping Company, operating vessels between Portland and the Orient and Europe. Capital has been increased to $2,500,000.

Schooner Bought, New York.—Seabury & deZafra, 150 Nassau street, New York, purchased the motor schooner Jayo in the interest of clients and have instructions to secure additional vessels of from 350 to 400 deadweight tons, and also one of about 800 deadweight tons for the same clients. They are also interested in steel steam or fuel oil engined vessels of similar size.

New Lines, Boston, Mass.—The Moss Line, through the International Mercantile Marine, 9 Broadway, New York, announces a service from Alexandria to Boston via Gibraltar, Algiers and Malta. Rogers & Webb also announce a new service between Boston and Marseilles, Genoa, Naples and Trieste. This company has had allocated to it the 7,800-ton steel steamer Clavarack. Future sailings will probably be monthly.

Purchase Ex-German Vessels, New York.—The Panama Railroad Steamship Line, 24 State street, New York, has arranged for the purchase of four ex-German vessels which have been operated by it for the past two years, for which, with a total tonnage of 15,569 deadweight tons, the line will pay $3,000,000. The company also purchased the Royal Mail Steam Packet Company's waterfront property at Colon, C. Z., for $250,000.

Harriman Sells Steamship Company, New York.—The Coastwise Transportation Company, recently acquired by W. Averill Harriman & Company, 165 Broadway, New York, has been sold to the American-Hawaiian Steamship Company, 8 Bridge street, New York. Through the purchase the latter company gains title to a fleet of ten steel ships with a deadweight capacity of 76,500 tons. Officials of the company announce that the entire fleet has been chartered for trans-Atlantic coal business for three years on satisfactory terms.

Freight and Passenger Lines, New York.—The Raporel Line of the Clyde Steamship Company, Pier 36, North River, has established a passenger service between New York and Hayti, Virgin Islands and the Windward Islands, and the first regular transatlantic freight service from Philadelphia to Avonmouth and Hull, England. Shipping Board tonnage has been assured the Mallory Steamship Company Pier 49, North River, for the freight service. The Raporel Line has established offices in the Commercial Trust Building, Philadelphia.

Shipping Board Sales, New York.—Shipping Board vessels sold include three cargo and passenger steamers—the Santa Theresa, 5,300 tons, the Santa Elisa, 5,300, tons and Santa Malta of 9,400 tons—for $5,250,000, also the ex-German liner Garland, 4,200 tons, for $174.60 a ton to W. R. Grace & Company. The ex-German ships—Yazoo, of 2,200 tons, and the Lake Dunmore, of 2,185 tons—were sold to Fernandez Hermanos, of Manila, for $250,000 cash on delivery and a New York concern at $200 a ton, respectively. Several small vessels were also sold by the Shipping Board. The Anderson Overseas Corporation, 165 Broadway, sold the Marshall, a 4,000 deadweight ton new steel cargo ship, to Henrik Ostward, of Bergen, Norway. The Lake Flatonia, about 4,000 deadweight tons, of the same type, was sold to the International Merc ntile Company. The same corporation completed arrangements for the sale of fifteen steel ships of 3,000 tons each, of the Lake type, to foreign concerns. Ten were sold to the Lloyd Royal Belge for $6,086,000, and five to a French company for $3,100,000. An agreement was reached by the Roumanian Government with the Shipping Board for the purchase of twelve steel cargo ships of 5,100 tons. The Lake Festus, a 3,000-ton vessel, was sold to the International Maritime Corporation, 44 Whitehall street.

FOREIGN MARITIME MATTERS

Tankers, Sweden.—The Commercial College at Stockholm has granted a subsidy of 8,000,000 kroner, covering about two-thirds of the cost of two 6,000-ton tankers to be built for Swedish owners.

Marine Oil Engines for England.—It is reported that the British Government is placing orders for large marine oil engines for installation in merchant ships to be built at the Chatham, England, Dockyards.

Cargo Steamers, Sweden.—The Kockum Yard, at Malmo, has an order to build one steel cargo steamer of 6,500 tons deadweight for the Swedish America-Mexico Line. One motorship of 4,450 tons deadweight will be built at Landskrona for Rederi A. B. Sverige, Levante.

Finnish Steamer, Danzig.—The Schichau Yard, in Danzig, has received an order to build the first Finnish trans-oceanic steamer, which is to be 7,300 tons deadweight. The vessel will cost 8½ million marks and is to be completed on November 1 of this year. She will be the largest steamer of the Finnish merchant marine.

Grain Steamers, Birkenhead.—The Byron Steamship Company, Ltd., of London, has placed an order with Cammel & Company, Ltd., for the construction at their Birkenhead shipyard of two grain-carrying steamers for service in the eastern Mediterranean. The vessels will be provided with geared turbine propelling machinery.

New Shipyard, Gloucester, South Wales.—A site at the head of the Monk Meadow dock has been acquired by a private limited company for ship repairs and building. Ellis Brothers, Bigham & Morris, Limited, will have the shop and offices, and T. V. Ellis, former manager of the Finch shipyard, Chepstow, is the head of the movement. The nominal capital is 7,000 pounds sterling.

Cargo Steamers, France.—The Chantiers et Ateliers, South East, have been ordered to build two steel cargo boats of 7,000 tons deadweight each for Cie. Générale Transatlantique. Chantiers de la Loire will build four steel cargo steamers 480 feet long by 59 feet beam by 46 feet deep. They will be named Jamaique, Kerguelen, Islande, Lipari, and are for the Chargeurs Rounis.

Motorships, Newcastle.—The Otto Thoresen Line, of Christiania, Norway, is having two sister motorships built by Wood, Skinner & Company, of Newcastle-on-Tyne. They have a deadweight capacity of 2,200 tons each, 260 feet in length, and are to be fitted with a 1,400 indicated horsepower, six-cylinder engine of the Werkspoor type, built in Holland. The cylinders are 560 by 1,000 mm.

Norwegian Steamers, England.—The Norwegian firm of Fernley & Eger have placed orders with English builders for ten steamers totalling 54,000 tons deadweight. Six of these are for the Garonne Company and will be used in the timber and wood pulp trade. Two are for The Aker Company, and two for the Glitre Company. All are to be delivered in the course of the year, and all except one will use oil fuel.

Salvage Work, England.—Maritime Salvors, Ltd., a new company, has acquired a permanent base of operations at Newhaven for salvage work. It has bought two of the best salvage vessels of the United States Government, which have been renamed and are fitted up with the latest appliances, including a flame cutter so devised that an oxy-acetylene flame can be used under water to cut holes in sunken vessels for cargo and machinery salvage.

Ships to Be Built, Melbourne, Australia.—The Senior Trade Commissioner states that the Commonwealth Government has decided to build twenty ships, in addition to the existing programme. The vessels will be shelter-deck, 331 feet between perpendiculars, 48 feet beam by 33 feet 7 inches depth molded to shelter deck. They will carry about 6,000 deadweight tons on 23 feet 8 inches draft, and have a capacity of about 338,000 cubic feet. The propelling machinery will be triple-expansion engines and Babcock & Wilcox boilers capable of giving a speed of 10½ knots, and using either coal or fuel oil. It has also been decided to construct four or six larger vessels, 520 feet length overall, 62 feet 3 inches beam, by 45 feet depth molded. They will carry about 12,800 tons deadweight on 30 feet draft. Their cubic capacity will be about 700,000 feet, of which about 250,000 will be insulated for carrying frozen meat. They will ha e twin-screw, quadruple-expansion engines, with watertube or Scotch boilers using coal or oil fuel, developing 7,300 horsepower and a speed of 13 knots loaded.

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